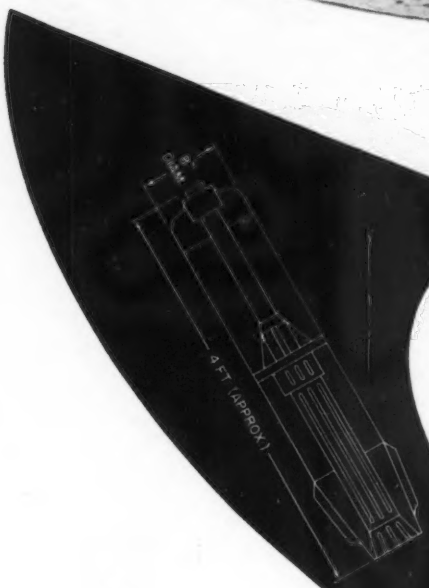
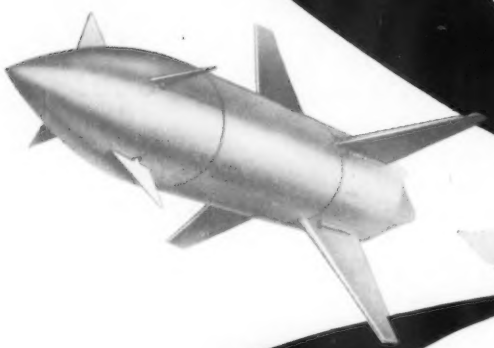
# AIRCRAFT AND MISSILES

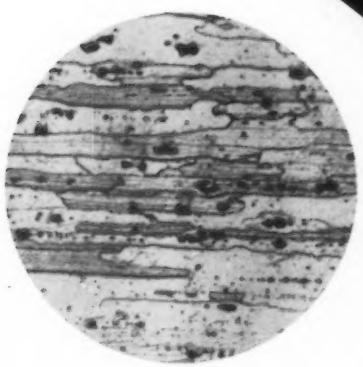
*integrating*

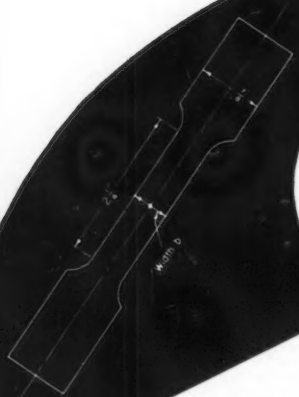
DESIGN
DEVELOPMENT
PRODUCTION
PROCUREMENT

NOVEMBER 1959









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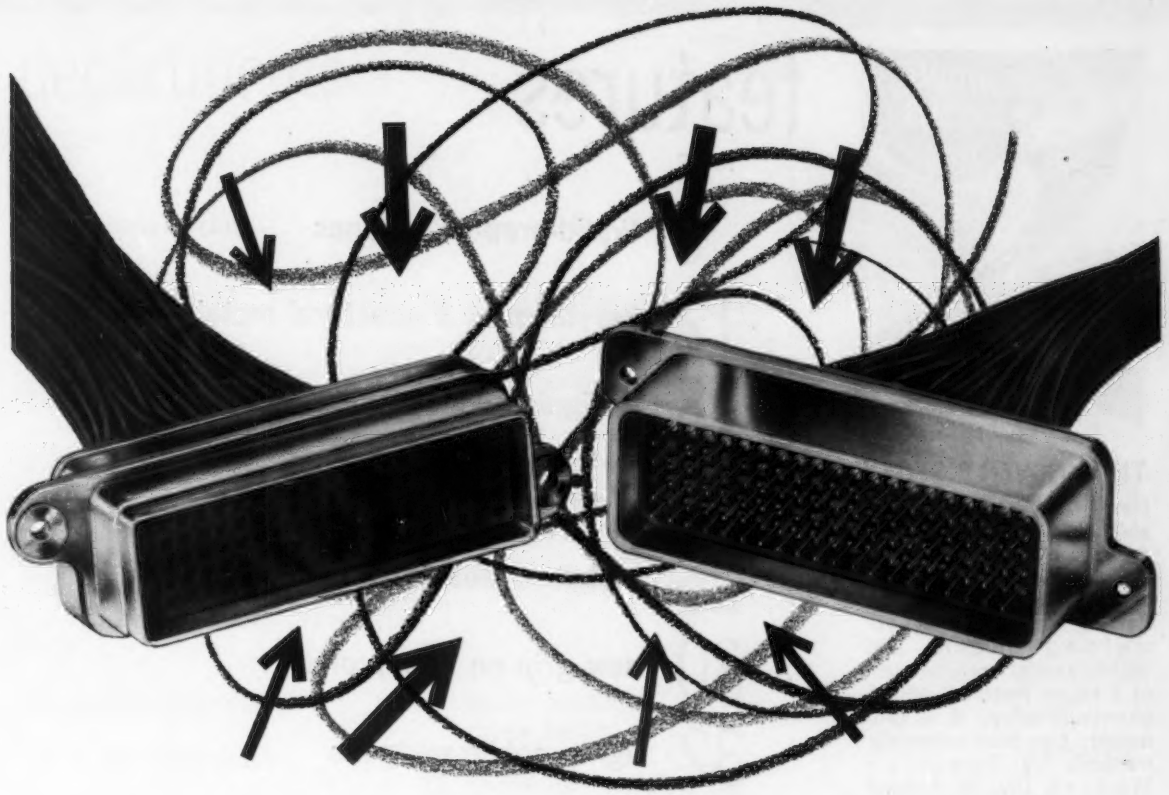

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AIRCRAFT AND MISSILES

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**THE COVER STORY**

Development of the storable, liquid pre-pack rocket engine is a significant achievement in both design and production. It has no moving parts, is an all-welded structure, and makes almost exclusive use of a single material—6066 aluminum alloy. It is produced by semi-automatic methods by Reaction Motors Div. of Thiokol Chemical Corp. Initial contracts are for Sparrow III and Bullpup.

---

**George T. Hook has been appointed publisher of Aircraft and Missiles. Mr. Hook continues as Chilton Co. vice president and publisher of The Iron Age.**

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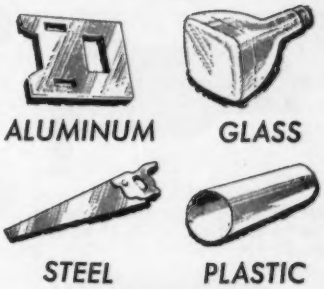

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## phase III–all about you

Here's the best part of the profile study we conducted on the Aircraft-Missile Engineer. We're going to tell you about your home life, how many of you are married, the number of children, the value of your home, etc.

Almost 93 per cent of the engineers are married. And for you single fellows, look out because the more money you make, the more likely you are to get married. When salary gets up over $17,000 a year, just about 100 per cent of the fellows are married. Of those who are married, the average is about 2.4 children. The median and the mode stand at two, one boy and one girl. Just as a matter of interest, 2 per cent of the married fellows have six or more children.

Over 88 per cent of you live in a house, 11 per cent live in apartments. Eighty-two per cent own their places.

The average market value of the home you own is $21,795, with the majority living in homes worth about $17,500. Most of you carry about $12,000 life insurance, with the average number coming out to $18,709. The biggest holders of insurance are the 40 to 49 age-bracket. These men are carrying well over $20,000 personal life-insurance that they are paying for themselves. This does not include company life-insurance programs. This group naturally drives up the average figure.

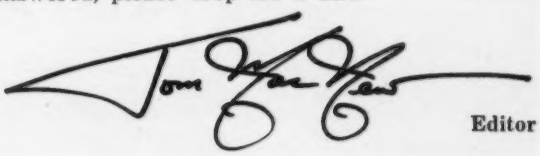
Well, 99.6 per cent of the aircraft-missile engineers own cars. Of this group 41.7 per cent own two or more cars. There are more two-car families in the 40 to 54 age-bracket than there are single-car owners. Most of you drive Fords, with Chevrolet and Plymouth coming in second and third. Highest among the foreign cars is Volkswagon, at 3.6 per cent. It is interesting to note that 1/10 of one per cent drive antique automobiles. As far as the year of manufacture, most are 1953 and above, with the majority being 1956 and 1957 vehicles.

We also wanted to find out if you attended a church as often as once a month. Sixty-five per cent of the engineers do. More engineers under 25, and engineers in the age group of 45 to 49, attend church than any other age classification.

Now for the big one, how much "dough" you are worth. We asked—"What is the present approximate value of your liquid assests?". Well, most of you have $1500 in the bank or in stocks and bonds. But the average is much higher, up to and over $9000. This is so because 37 per cent of the men 55 years of age and over, have liquid assets of more than $25,000, ten per cent of that total are over $100,000. The figures fall off rather sharply as we go through the other age classifications. For example, if you are under 25 and up to 29 you average out at $3000, 30 to 34 $5000, 35 to 39 $7000, 40 to 44 $12,000, 45 to 49 $17,000, 50 to 54 $19,500 and 55 and over $34,400.

Now for the question that we had a lot of fun with. What brand of cigarette do you smoke? We've all seen the commercials and you often wonder, well just what do the people in our field smoke. Gentlemen, you smoke Kents more than any other cigarette, with second going to Camels. There were 19 cigarette brands mentioned. Again, an interesting point, is, if you're between 40 and 44 the leading cigarette is Camels, but only in that age classification, in all others the cigarette preference is Kent. The third cigarette was Pall Mall, and the fourth Chesterfield. But there is a significant point to this smoking question. We wanted most to know if you do smoke. Only 57.4 per cent of the engineers smoke, and 73 per cent of those who smoke, smoke cigarettes.

Within the next couple of months, we'll publish an article summing up the entire profile study, giving you a lot more facts and figures than we presented in the three editorials. Again, if there are any specific questions you wish answered, please drop me a line.



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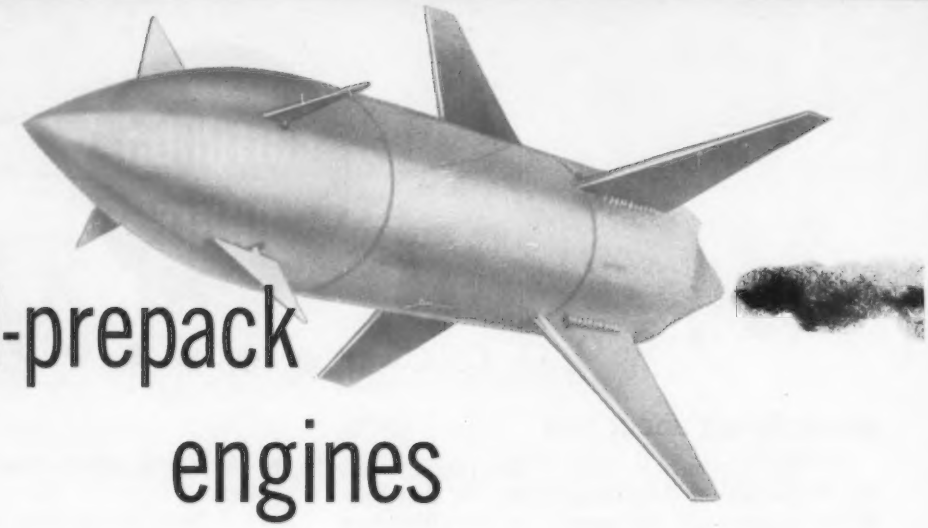


# liquid-prepack engines

## simplified design permits semi-automated production, eliminates long countdowns, and allows storability in extreme environments

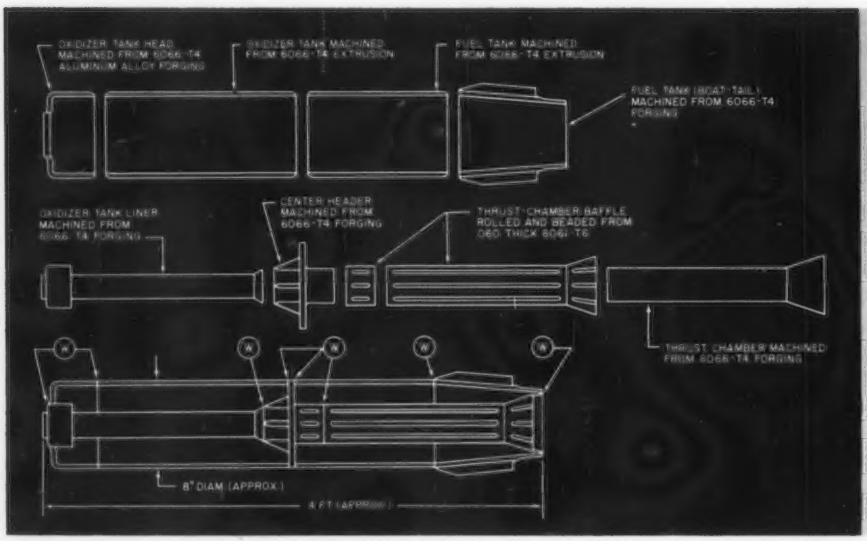
by S. Peter Kaprielyan and John P. Kushnerick

Loaded with propellant, and ready for firing or storage, a new breed of liquid rocket-engine is coming off a semi-automated line at Reaction Motors-Bristol.

First two versions of the engine designated Guardian I, and Guardian II will respectively replace solid motors now used in Sparrow III and Bullpup.

Unencumbered design and ease of manufacture mark milestones in rocket technology. Simplicity of the final design belies the fact that workable hardware utilizing the storable liquid-prepack concept has eluded the best efforts of missile engineers since WWII.

Developed under Navy contract, the first operational engine, Guardian I, has already been delivered in initial production lots. Tool-up is now underway for Guardian II which will be delivered in production lots by spring of 1960. This engine is under a separate Navy contract of $3.5 million.


OXIDIZER TANK HEAD MACHINED FROM 6066-T4 ALUMINUM ALLOY FORGING
OXIDIZER TANK MACHINED FROM 6066-T4 EXTRUSION
FUEL TANK MACHINED FROM 6066-T4 EXTRUSION
FUEL TANK (BOAT-TAIL) MACHINED FROM 6066-T4 FORGING
OXIDIZER TANK LINER MACHINED FROM 6066-T4 FORGING
CENTER HEADER MACHINED FROM 6066-T4 FORGING
THRUST-CHAMBER BAFFLE ROLLED AND BEADED FROM .060 THICK 6061-T6
THRUST CHAMBER MACHINED FROM 6066-T4 FORGING
W
8" DIAM (APPROX.)

**Design configuration of Guardian I liquid-prepack engine is shown. Welded seams are indicated by "W" notation.**

Snowballing effect of the achievement is evidenced by Reaction Motors receiving an extended Air Force feasibility study for storable "high-energy" fuels in large pre-packaged engines. A 50,000 lb thrust engine of this type was built and fired earlier this year.

About 100,000 sq ft of the facility that parent-Co. Thiokol acquired from Hunter-Bristol Mfg. Co. is geared for production of Guardian series by the Reaction Motors Div. Units are manufactured complete from raw-stock to crating in this space. Part of the production line is conveyorized to handle follow-on programs. Equipping the facility involved the largest single order of machine tools placed by a missile firm in the last 12 months.

### Design Concept

Pre - packaged liquid - propellant thrust units have a design simplicity almost approaching that of solid-propellant engines. They can be stored in the "ready" state in severe, natural environments.

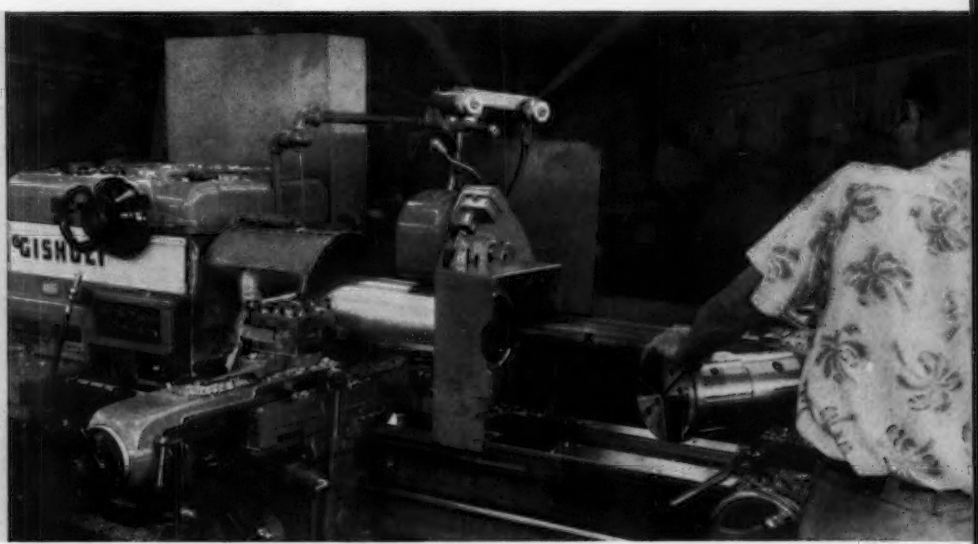
The engines use no pumps, shafts, valves, or similar moving parts. A solid-charge propellant pressurizing medium is permanently sealed into a tankage shell integral with thrust chamber. An electrically-initiated igniter cartridge is used to fire the solid charge and start the engine. Missions for which these power-plants are intended require no throttling provision. Tedious count-down has also been completely eliminated by pre-packaging.

### Three Basic Problems

Three basic problems delayed realization of this concept:

- Propellant combination and tankage material suitable for long-term storage.
- Choice of compact energy source to pressurize and expel propellant.
- Choice of an injector and initiating device incorporating ruggedness and producibility.

Guardian I and II engines are identical in principle, the latter being a larger and more powerful version. Inhibited red fuming nitric acid is used as oxidizer, an amine-base liquid serves as fuel. Both liquids are contained in



Sparrow III oxidizer tank is machined on Gisholt turret lathe.

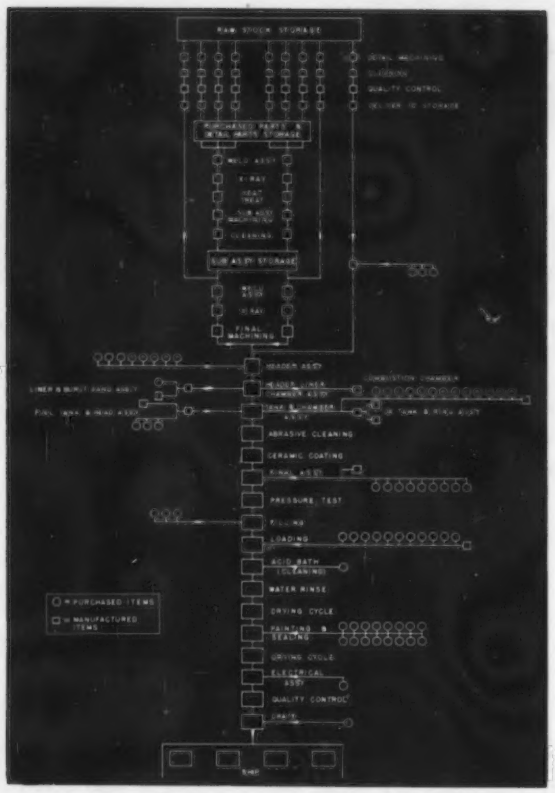



Diagram shows production process sequence of Thiokol Chemical Corp., Reaction Motors plant, Bristol, Pa.

Prior to welding, powerplant-structure components are cleaned by "merry-go-round" setup of the Udylite Corp.

6066-T6 aluminum alloy tankage making up the cylindrical body of the powerplant.

The 6066 alloy is a development of Harvey Aluminum; it is supplied by Alcoa in the T4 condition (50,000 psi UTS) as forgings and extrusions. This alloy was chosen for its strength, corrosion resistance and good machinability and weldability. Both machinability and weldability characteristics are comparable to those of 6061-T4.

### Reliability Through Simplicity

Outstanding simplicity is based on these main features:

- Material used is all 6066 aluminum alloy except for a copper nozzle, and 4130 steel bar of 3-in. diam.
- Extruded and forged raw-stock is machined, then powerplant is integrated fully by automatic inert-arc welding.
- No mechanical fastening is used for joining of structural elements.
- After propellants are loaded, tankage is sealed by welding, leaving no possibil-

Oxidizer tank is shielded-arc-welded to its liner, in vertical setup.

ity of leakage or evaporation.

Overall unit is made up of two tubular structures. Outer shell includes oxidizer and fuel tanks. The latter tank has machined slots for installing tail fins. Inner tubular-structure consists of pressurizing-charge tube, center header, and a thrust chamber.

The center header acts as separation bulkhead between oxidizer and fuel compartments; header also houses a cluster of multi-orifice injector fittings. Thrust chamber is regeneratively cooled by the amine-base fuel. It consists of a thin, beaded, 6061 aluminum-alloy jacket over a 6066 machined forging.

Initial fabrication phases consist of machining of extruded 6066-T4 tubular sections to ±0.005 in. roundness, and beveling of tube-ends preparatory to welding. Good surface finish is obtained at 900 to 1000 SFPM, using carbide cutting tools.

### Tool Development Program

To develop the machine tools needed, machine-tool builders were supplied specifications, and asked to produce several sample parts. These parts were produced at the machine builders' facilities in cooperation with Thiokol tool engineers. The machines were then shipped to the Bristol plant, and a second batch of parts was produced. When these met specifications, actual production run was begun. All major equipment was tested and bought on this basis.

### Assembly Technique — Engine Core

The forged center-header of the inner-core assembly is the structural member around which the entire powerplant is progressively assembled. Front-end of the center header attaches to the pressurizing-charge tube, aft end attaches to the thrust chamber. The pressurizing-charge tube is rough-bored from a tubular forging; bore is then flame sprayed with Rokide "Z" (see A&M June 1959, p. 22) and ID is machined to final dimensions by tracer control. Thrust chamber is machined from a forging, inserted into its baffle jacket, then both chamber and jacket are welded to center header.

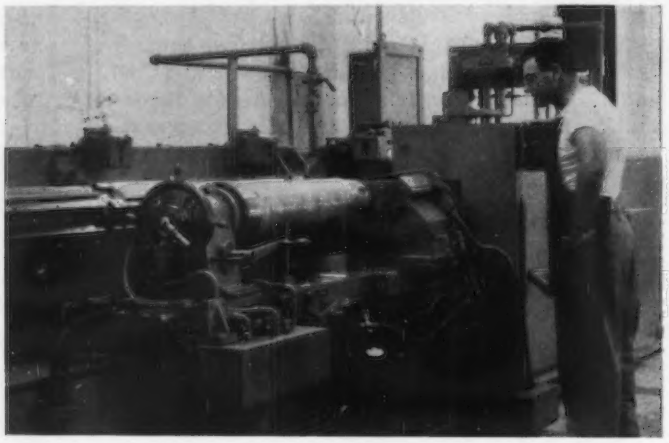
*continued on next page*

**Integration of Guardian I inner-core assembly is completed in a simple fixture which swivels on two axes. Beaded jacket in foreground directs fuel over thrust-chamber for regenerative cooling.**

**Three main assemblies of Guardian I powerplant are shown prior to final assembly by welding.**

## liquid-prepack . . .

**continued**



**Completed powerplant is shown in Sundstrand broacher used for cutting of dove-tail slots in tail-fin pads.**

Final operation on core assembly involves welding a blast-deflector collar at front end of pressurizing-charge tube.

The powerplant is then ready to receive its outer shell, which consists of two forgings, and two extrusions. Oxidizer-tank head, at front of powerplant, and aft boattail-fairing with fin pads are machined from forgings; uniform cylindrical sections of oxidizer and fuel tanks are machined from extrusions. After joining oxidizer tank to its head, and fuel tank to aft boattail-fairing, both tanks are solution heat treated and joined to center header. To promote high-quality welds, surfaces to be joined are processed through alkaline dips and clear water rinses immediately before welding. Final welding operations join thrust-chamber nozzle edge to boattail-fairing, and oxidizer-tank head to pressurizing-charge tube at front. Integration of powerplant is complete at this stage.

Entire unit is then cradled in flame spraying machine for Rokide "Z" coating of thrust chamber ID. Spraying machine was produced by Sesco Mfg. Inc., Bridgeport, Pa., to Thiokol specification. Machine has provisions for automatic start, stop, and touch-up cycles. A dial shows spraying - probe position in thrust chamber throughout process.

**Flame-spraying of thrust-chamber with Rokide "Z" takes place after integration of powerplant.**

Last machining operation consists of broaching four dove-tail slots for the tail fins, and milling pockets for the launching lugs. Engine is then placed in a composite inspection fixture, and all dimensions and attach locations are checked for conformance to specification. Pressure and/or leakage tests are made on an in-process basis as sub-assemblies are built up and after final assembly, prior to filling and loading.

### Propellant Loading

Loading of propellants and pressurization charge takes place in a maximum-safety area, isolated from main facilities. From the time engines enter this area, till they are crated for shipping, they are kept suspended in conveyorized racks.

Propellants are loaded by remote controls accurate to $\pm\frac{1}{2}$ oz. A final welding operation seals-in propellants. An elaborate cleaning, drying, and painting sequence follows in rapid succession. Order of operations is as follows: clean, rinse, dry, zinc-chromate prime, dry, white-lacquer paint, dry, white-lacquer paint, dry, and air dry. Units are then cradled in wooden crates with separately encapsulated igniters and are ready for delivery.

✦

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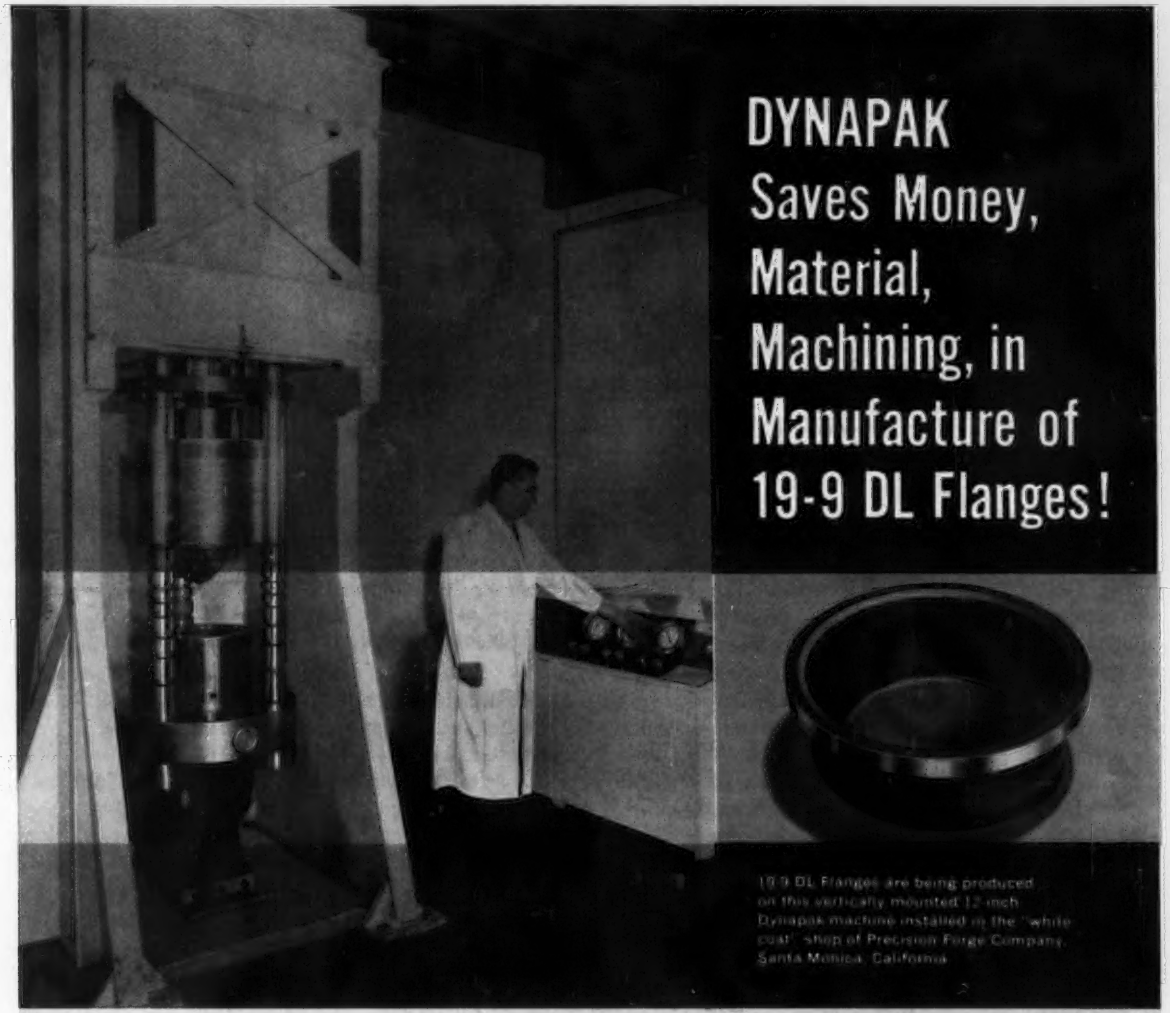

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- TOOLING: 50% of the cost of conventional forging dies
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PLUS

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AIRCRAFT AND MISSILES

SPECIAL STAFF REPORT—PART I

# beryllium as a structural

## light, stiff metal has great potential; extensive studies underway on all fabrication techniques, brittleness still main bugaboo

By 1970 nuclear and free radical power plants will largely replace the combustion powerplant for aircraft and spacecraft. Induced environment for aircraft skins will reach 2000°F as speeds level-off at Mach 4. Short-time exposures of 9000°F will not be uncommon for reentry vehicles. This indicates an abundant need for a material with good radiation properties, and a material with good high-temperature strength. The metal beryllium excels in both these areas.

Beryllium is almost as light as magnesium, and is about 50 per cent stiffer than steel. It is said to be superior to Inconel X, graphite, or copper as a heat absorber, with a six-fold weight advantage over the lightest of these. It has a melting point of 2345°F. And, it has the unusual ability to reflect neutrons when subjected to nuclear bombardment.

### Disadvantages Govern Use

But use of beryllium in structures will depend more on its disadvantages than on its mechanical superiority.

Beryllium is:

- Brittle, hence very difficult to fabricate.
- Costly, both to extract and fabricate.
- Toxic, hence requires special hygiene techniques.
- Scarce, by certain frames of reference.

None of these problems is insurmountable,

Billet for Mercury heat shield is examined ultrasonically prior to final forging. Structure represents furthest extension of state of art in forging beryllium.

considering the rate of progress in beryllium metallurgy. The first, brittleness or lack of three dimensional ductility, seems the real bugaboo. It is the ever-present foe that blocks, and frustrates attempts at fabricating useful structural shapes. It is the underlying problem for all other problems of immediate consequence.

Limited structural use of beryllium has been made by designers. None of the applications do justice to the metal's potential.

There are two major suppliers of beryllium in this country: Brush Beryllium Co., and Beryllium Corp. of America. Each uses two distinct steps in extracting the metal: (1) separation of beryllia (BeO) from beryl ore, and (2) reduction of beryllia to beryllium. As might be expected, two techniques are employed for separation of BeO. Beryllium Corp. uses a fluoride extraction, Brush uses a sulphate extraction. Practically all pure beryllium produced in U. S. is made by reduction of beryllium fluoride with magnesium. The fluoride is produced from BeO. The metal emerges from the process as small pebbles.

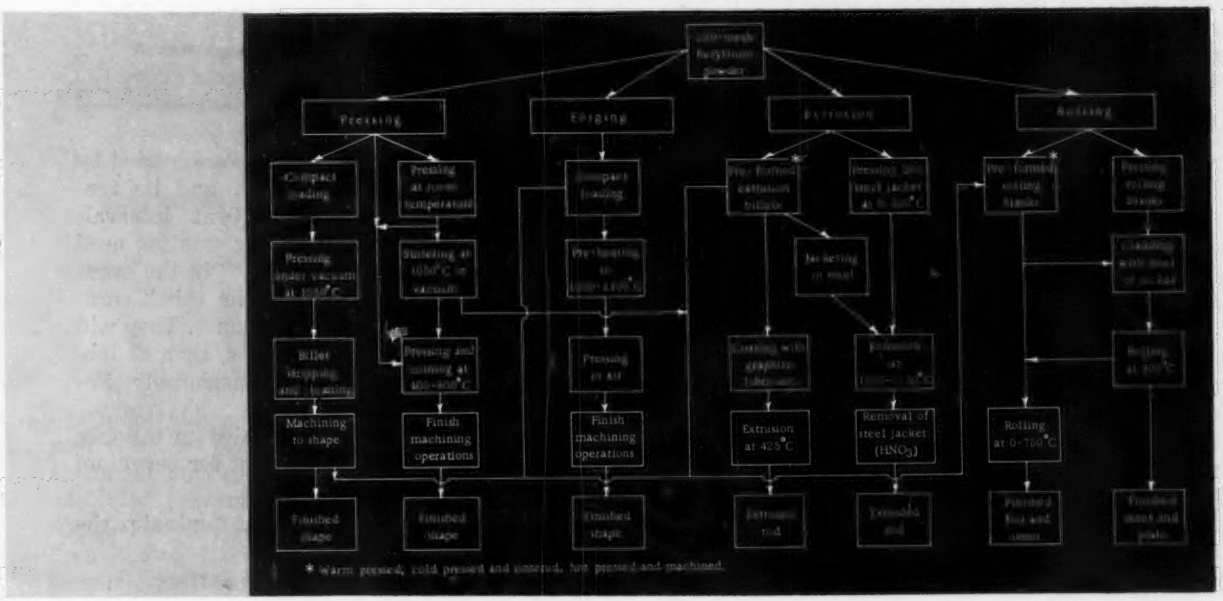
Fabrication of structures from beryllium metal so produced is by variations of the powder metal techniques. The pebble is vacuum, or inert atmosphere, cast to a rough billet. Billet is chipped, and the chips are attritioned to a fine powder (—200 mesh). The powder is fabricated to shape by either warm-pressing, cold pressing and sintering, or hot pressing in vacuum or inert atmosphere. These preliminary steps are followed by forging, extruding, or rolling (See Table 1).

### Purity of Powder

Purity of the powder, and nature and distribution of impurities profoundly affect final properties. Physical size of powder also has an important effect, since oxygen content is related to powder size. The more exposed surface the more oxygen. This follows since each particle is covered with a fine layer of BeO. In some studies Brush has concluded that with much over 2 per cent BeO, it is difficult to obtain full density in hot pressing. These ramifications indicate that minus 200 mesh particles are optimum.

Beryllium Corp. feels that the effects of BeO often work to advantage. The company has

**TABLE I. FABRICATON PROCEDURES FOR BERYLLIUM POWDER**



pressed for a relaxation in specifications which arbitrarily limit content to 2 or 3 per cent. BeO lowers thermal conductivity but increases ultimate tensile strength. Some "pure" BeO samples have been made with 100,000 psi UTS. Shapes have been hot pressed to 95 per cent density. Indications are that development of this metal might parallel that of pure beryllium.

### Extrusions

Northrop Corp. (Norair Div.) is acting as prime contractor on Air Force contract 33(600)-3691 aimed at developing extrusion techniques. An aircraft company was selected as prime because of the familiarity with the particular needs of the industry. Nuclear Metals, Inc., is performing the actual extruding. Investigation is programmed in 3 phases, and is aimed at producing a U-shaped channel 1.5 in. wide and 20 ft long. Approach is to extrude "bare," vs. cladding extrusion in stainless steel. The investigation is now in Phase II and target shape has not been reached. Some valuable data has been collected however.

During Phase I, Beryllium Corp. "competed" with Nuclear Metals. The former used their own sintered billets, the latter used QMV billets produced by Brush. Collective accomplishments were:

SPECIFICATION for best extrusion material was written. Composition is shown in Table II. One important aspect of this composition is the rigid control placed on maximum "tramp" elements. Iron, in particular, is a potent strengthener but is also an embrittler of QMV material.

TOOLING for the first phase of the investigation employed conventional oil hydraulic presses. Nuclear Metals used a 1000-ton press, Beryllium Corp. used a 1700-ton press. Although beryllium is light, it is extruded by "stream-line flow" as opposed to "shear" extrusion used for aluminum and magnesium. Methods are similar in some respects to those for steel.

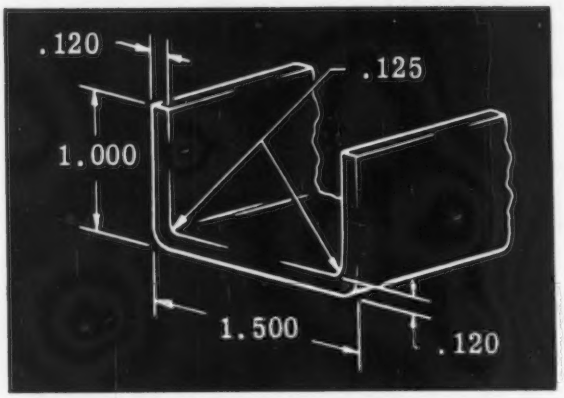
Beryllium's resistance to deformation makes necessary heavy equipment to avoid stalled presses and broken tooling. A "straightener" is employed as an integral part of the press to keep extrusion straight on exit from the die and while cooling. Precautions should be taken to prevent personnel from breathing toxic beryllium fumes. Air samples taken during tests revealed no appreciable increase in contamination from extruding bare.

Table II. Tentative Composition for Extruded Beryllium

| Element | Quantity |
|---|---|
| Carbon | 0.15% maximum |
| Iron | *1500 parts per million maximum |
| Nickel | 0.08% maximum |
| Copper | 0.05% maximum |
| Aluminum | 0.15% maximum |
| Manganese | 0.03% maximum |
| Silicon | 0.10% maximum |
| Chromium | 0.05% maximum |
| Magnesium | 0.05% maximum |
| Beryllium Oxide | 1.50% maximum |
| Beryllium | Remainder |

Total impurities (other than beryllium oxide) shall not exceed 0.50%.

* 700 parts per million desired.



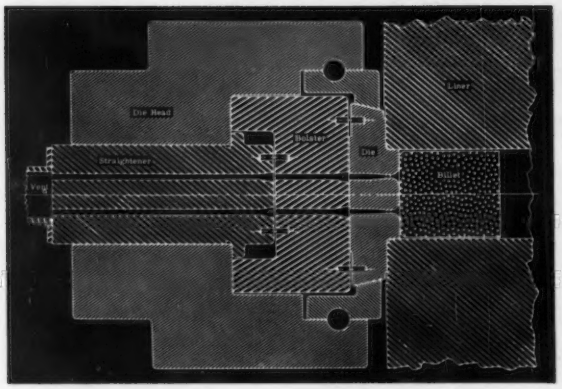

Norair, Div. of Northrop Corp., heads extrusion program aimed at developing "bare" extrusions techniques for this shape.

| | |
|---|---|
| Straightness: | 0.0125 - in. per ft of length |
| Twist: | (circle size) ½° per foot of length; 5° total maximum |
| Angularity: | (Less than 0.188 in. thick) ±2° at any point of measurement |
| Length: | ± 0.250 - in. |
| Flatness: | (Cross-wise dimension) 0.004 in. per in. |
| Surface Roughness: | 100 microinch general. |
| Target Length: | 20 linear feet |

DIE DESIGN AND MATERIALS were guided by beryllium's highly abrasive effect, and its tendency to fracture at intermittent intervals (rattlesnake). A secondary finding was the need for a die that would not "wash-out" in the event lubrication became inadequate. The cobalt-chromium alloy dies gave best performance. They will probably be used until all variables, such as lubricant inconsistency can be considerably improved.

LUBRICATION must be provided on the face of the die. To be effective, lubricant for beryllium extrusion must:

- Not react with or contaminate the metal.
- Wet and adhere to billet surface.




Nuclear Metals Inc., is doing actual extrusion in Northrup study. Shown is typical press arrangement.

TABLE III. TOOL DESIGN AND USE DATA

| Tool Geometry | Turning | Forming |
|---|---|---|
| Back rake angle, deg | 0 | +8 |
| Side rake angle, deg | 7 to 8 | None |
| Side-cutting-edge angle, deg | 12 to 15 | None |
| End-cutting-edge angle, deg | 8 to 15 | None |
| Side relief angle, deg | 7 to 10 | 7 |
| End relief angle, deg | 7 to 10 | 7 |
| Nose radius in. (continuous cutting) | 1/64 to 1/32 | None |
| Nose radius in. (interrupted cutting) | 1/16 | None |
| **Speed, Feed, and Depth of Cut** | | |
| Speed, fpm | 150 to 250 | |
| Feed, ipr | 0.01 to 0.015 | |
| Depth of Cut, inch | Up to 0.100 | |
| Horsepower | 1 hp per cu in. per minute | |
| (Speeds up to 1000 fpm may be used for very short intervals.) | | |
| **Tool Materials** | | |
| Carbide Grade C-1 for interrupted cutting. | | |
| Carbide Grade C-2 for continuous cutting. | | |

TABLE IV. TOOL DESIGN AND USE DATA—MILLING

| Tool Geometry | Rough and Finish Milling |
|---|---|
| Back rake angle, deg | 0 to 10 |
| Side-cutting-edge angle, deg | 7 |
| Face-cutting-edge angle, deg | 3 to 7 |
| Side relief angle, deg | 10 to 15 |
| End relief angle, deg | 10 to 15 |
| Land, in. | 1/32 to 1/16 |
| **Speed, Feed, and Depth of Cut** | |
| | Roughing / Finishing |
| Speed, fpm | 60 to 100 / 100 to 150 |
| Table Feed, ipm | 3 to 6 / 3 to 6 |
| Depth of Cut, inch | No data / No data |
| **Tool Materials** | |
| Carbide Grade C-1 for rough milling. | |
| Carbide Grade C-2 for finishing milling. | |

---

- Possess body and lubricity.
- Insulate the die from the metal being extruded.
- Become viscous at proper temperature.

Glass best fills these requirements.

EXTRUSION SEQUENCE is to:

- Heat billet in inert environment.
- Remove billet from furnace.
- Roll billet in glass powder, flock, or both.
- Place billet in container on press.
- Bring ram home at desired speed.

Beryllium Corp. heated billets in 10 per cent NaCl, 90 per cent $BaCl_2$ solution. Billet was placed in steel jacket to prevent contamination and also prevent billet from floating. Nuclear Metals coated billet in water-soluble glass slurry, then heated it in argon atmosphere. Temperatures ranged from 1635 to 2000°F after preheat.

Billet temperature at time of extrusion was not determined. Transfer time was about 15 sec and some temperature loss naturally occurred. Billet container was maintained at 900°F. Optimum extrusion temperature is believed to be 1750 to 1850°F.

Starting tonnage for U-shaped channel illustrated ranged from 1438 to 1700 tons on the large press and from 457 to 949 tons on the small press. Billet variables caused such a large spread. Optimum extrusion reduction ratio was found to be between 20 to 1 and 35 to 1. Ram speeds varied from almost zero to 1½ in. per sec. Ram speed had no apparent effect on extrusion quality.

TEST RESULTS, using special techniques to take care of extreme brittleness, were as follows:

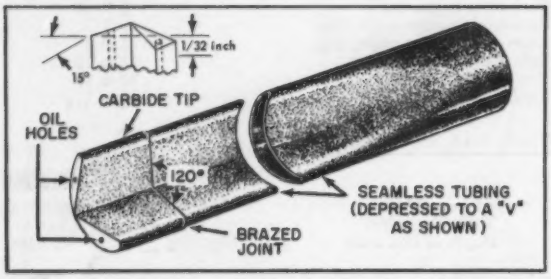
| | |
|---|---|
| UTS | 80,700 psi |
| Yield (0.2% offset) | 54,100 psi |
| % elongation in 7 in. | 3.5 to 6.0 |

Norair feels bare extrusion technique will produce useful shapes and lengths within 2 years.

## Sheet Rolling

Air Force sheet rolling program is now under direction of Brush Beryllium on contract AF 33(600)-35829. However, other organizations are also neck-deep in studies, since sheet materials are of prime import.

When close attention is paid to the grain orientation in the rolling process, 30 to 40 per cent elongation can be achieved in all directions in the plane of the sheet. This amounts to two-dimensional ductility. In the third direction, ductility is almost nil. To date, physical properties in the sheet are very inconsistent. If ultimate tensile strength of 70,000 psi could be obtained with certainty, Beryllium Corp. feels the maker would have plenty of buyers. Sheets 0.060 in. thick and trimmed to 20 x 40-in. flat have been delivered to Martin-Denver for forming and joining studies. Beryllium Corp. was setting up to




**Considerable difficulty may be experienced in drilling deep holes in beryllium. With conventional twists and drill materials, drill may bind. Shown is one type of single-fluted rifle drill that has been successful.**

roll 0.020-in. thick material in widths up to 44 in., and lengths of 105 in. at this writing. Virtually every major aircraft and missile company has received some beryllium sheet from the rolling program. Lockheed figures to be one of the largest users of structural beryllium in the immediate future. Polaris program has been the basis of most studies; nuclear rocket study recently awarded by NASA will also bring some attention to beryllium.

Brush, jackets sintered blocks in steel, heats to about 1000°F rolls to about ⅛ in. From here pack rolling similar to that used in titanium is employed. Sheet and plate are rolled bare down to "a few mils," and 30 in. wide.

### Forging

Furtherest extension of the forging art has come from NASA decision to use beryllium heat sink as back-up material for Mercury capsule. This forging work was done by Brush in cooperation with Alcoa. Brush first hot-pressed a 62-in. diam billet. Heat, pressure, and vacuum were applied to QMV powder simultaneously to do the job. After inspection and preliminary machining, the billet was shipped to Alcoa-Cleveland, where it was jacketed in steel and heated to 2000°F. The billet was removed from the jacket, placed in the 50,000 ton press, and "hot upset" to a saucer-shape, 80 in. across and 3-in. thick.

Wyman-Gordon fabricated the first closed-die forging of beryllium on their 18,000 ton press some months ago. This program was in cooperation with Beryllium Corp. More accurately described as "hot press-forging", this feat was achieved by packing a double-walled cone of 1020 steel with powder, heating it, and squeezing it down about 85 per cent. Steel jacket was then removed with $HNO_3$ pickle. The press-forging was carried out at 2000°F, and pressure application was for about 30 sec.

Forging may play an important role in the preliminary processing of beryllium, as well as in making final shapes. Wyman-Gordon has such a strong faith in the metal and the forging process that a great portion of their facility is now being geared for the handling of beryllium from powder to final shape. Use of forged stock for rolling to sheet has been encouraging.

Tests at The Martin Co. tend to indicate a structural superiority in sheet fabricated from forged (or hot-upset) stock. Samples showed an UTS of 70,000 psi, with about 20 per cent elongation in the plane of the sheet, and over 1 per cent elongation in the short tranverse direction. Bending tests in particular showed the superiority of this type sheet.

North American Aviation Corp. is conducting their own forging investigation. Canadian Steel Improvements facilities are being used in this program.

### Machining

Beryllium machines like cast iron, but is more abrasive to tools. There is a great tendency for the metal to chip when the tool leaves the cut. This is because of brittleness. The tendency can be relieved in turning by chamfering both ends of the work piece to finished diameter before turning.

Carbide tools are normally used for turning, milling, drilling, at speeds of 250, 150, and 100 sfpm respectively. Method of chip collection and air exhaust also govern turning speed. AEC recommendations are to regard the metal as "potentially toxic." Maximum allowable concentration of beryllium in the air should be 20-micrograms per cubic meter.

Extreme care must be taken to preserve chip cleanliness for reclaiming. Some companies avoid cutting oils because of this. Cimcool S-2 (Cincinnati Milling Machine Co) gives good results with mixtures of 40 to 1 for milling, drilling, and grinding, and 10 to 1 for reaming and tapping, where cutting fluids are mandatory.

Exact tool design and speed-feed rates can be obtained from accompanying tables. These should serve as a guide, or starting point and should not be regarded as final.

✦

*Look for Part II of this special report by the editors of Aircraft and Missiles. The subject will be joining beryllium.*

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of this article can be obtained by writing on company letterhead to
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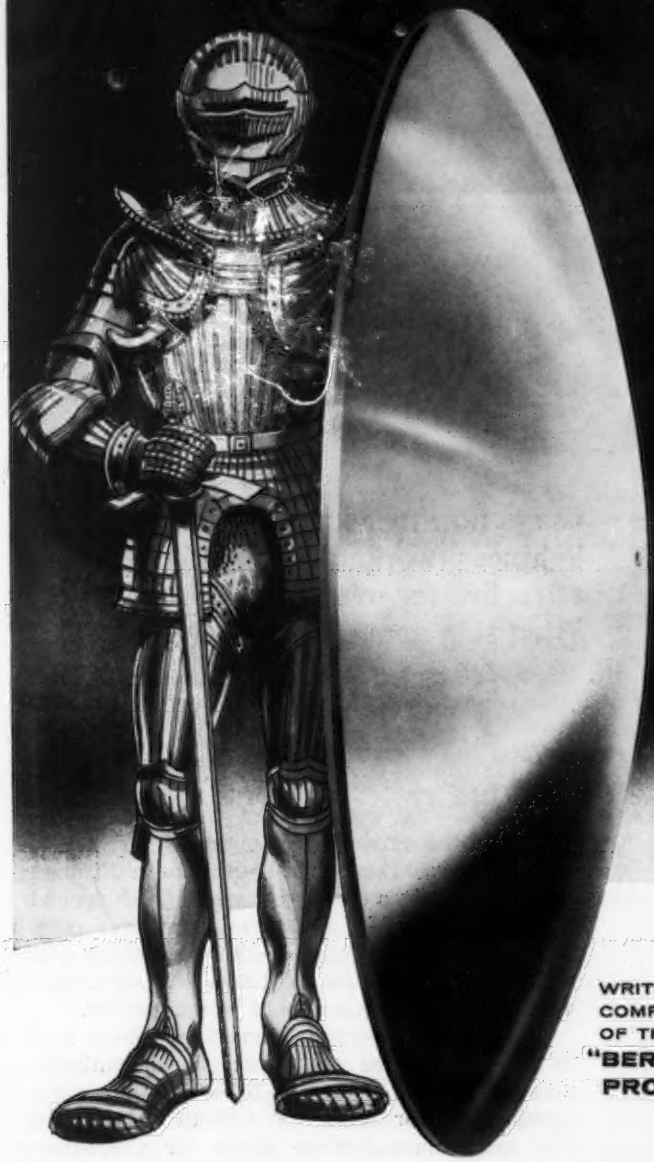
# SHIELD FOR THE BATTLE OF SURVIVAL IN SPACE



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# BRUSH BERYLLIUM

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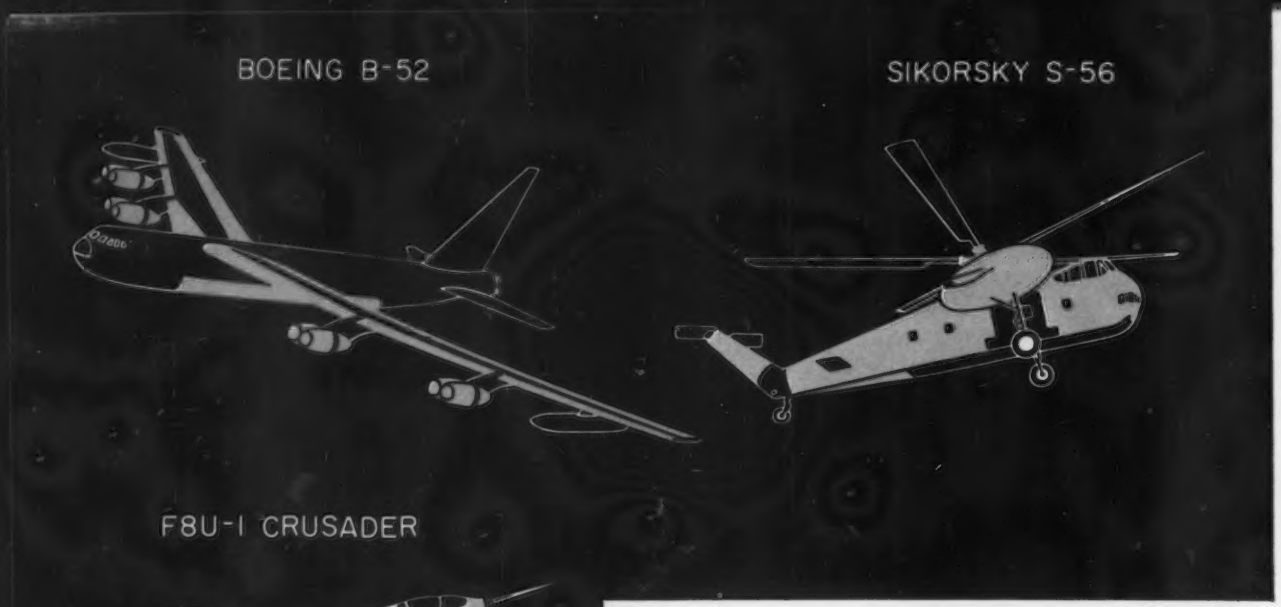
***beryllium · beryllium oxide · beryllium alloys***




# designing with

## usage now measured in tons; lightness, workability attractive for missiles; Titan skin about 40 per cent mag-alloy

**Designation, composition, and available forms of magnesium-thorium alloys are given.**

| Alloy Designation | | Nominal Composition, weight per cent | | | | |
|---|---|---|---|---|---|---|
| ASTM | Equivalent | Th | Zn | Zr | Mn | Forms Produced |
| HK31A | HK31XA | 3.0 | — | 0.7 | — | Sand castings, sheet, and plate |
| HM21A | HM21XA | 2.0 | — | — | 0.5 | Sheet, plate, and forgings |
| HM31A | HM31XA | 3.0 | — | — | 1.5 | Extrusions |
| HZ32A | ZT1 | 3.0 | 2.1 | 0.7 | — | Sand castings |
| ZH62A | TZ6 | 1.8 | 5.7 | 0.7 | — | Sand castings |
| HM11XA | — | 1.2 | — | — | 1.2 | Die castings |
| HZ21 | ZTX (British) | 2.5 | 1.0 | 0.6 | — | Extrusions, sheet, and forgings |
| — | TZ4 (British) | 2.0 | 4.0 | 0.7 | — | Castings |

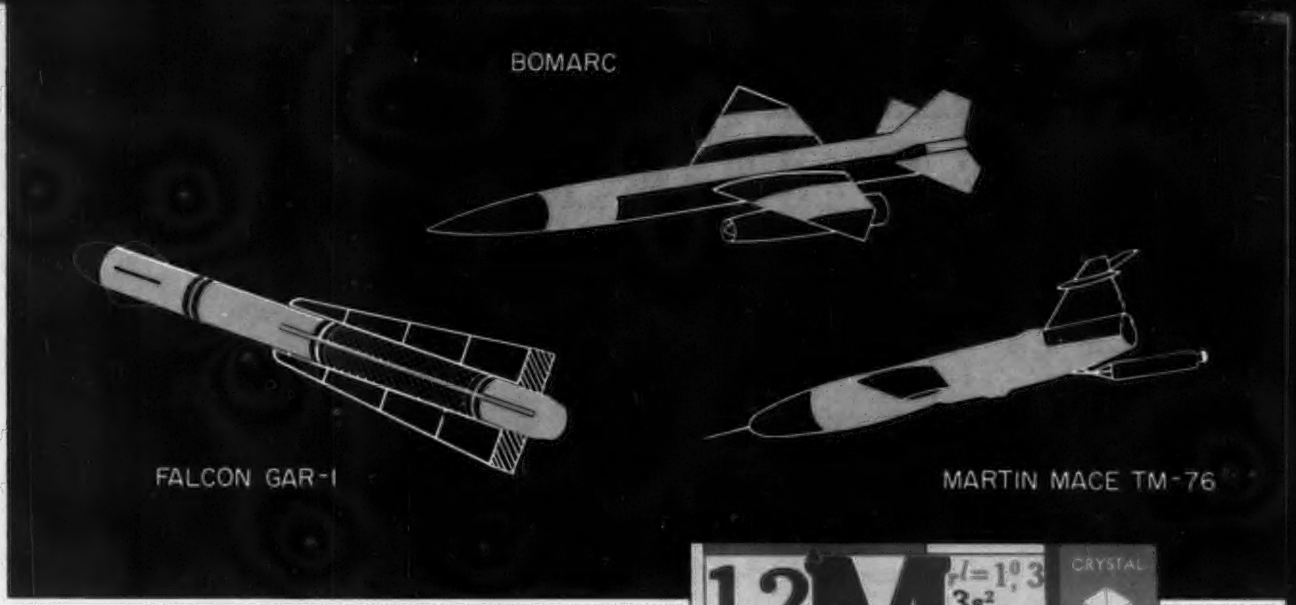
**Modulus of elasticity is given for cast magnesium-thorium alloys at room and elevated temperatures (Modulus value: psi x 10).**

| Alloy Designation | Temper | Form | Temperature, °F | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | R.T. | 300 | 400 | 500 | 600 | 700 |
| HK31A | T6 | Sand Cast | 6.5 | 6.1 | 5.9 | 5.7 | 5.5 | — |
| HZ32A | T5 | Sand Cast | 6.5 | 6.1 | 5.9 | 5.7 | 5.5 | — |
| HM11XA | F | Die Cast | 6.2 | 6.2 | 5.9 | 5.8 | 5.7 | 5.6 |

In the producibility spectrum of metals, extending from the workhorse to the exotic, magnesium occupies a distinctive spot. It is light and extremely workable; and among the newcomers to the aircraft and missile industry it is now reaching the tonnage-use status. Viewed in another way, this spells tons of weight-saving.

Application-wise, magnesium alloys may be grouped in three categories: (1) conventional, room-temperature alloys; (2) magnesium rare-earth alloys for service at 350 to 450°F; and (3) magnesium-thorium alloys for short-time service up to 700°F.

By its high-temperature properties, the last group is of particular interest to aircraft and missile designers. Eight thorium-bearing magnesium-base alloys are currently offered for elevated-temperature service. These are tabulated




# magnesium

*This article is based on a recent report by the Defense Metals Information Center, Battelle Memorial Institute, and data from The Dow Chemical Co.*

| Alloy Des. | Temper | Form | Room Temperature UTS 1000 psi | Room Temperature YS 1000 psi | Room Temperature % E in 2 in. | 300 °F UTS 1000 psi | 300 °F YS 1000 psi | 300 °F % E in 2 in. | 400 °F UTS 1000 psi | 400 °F YS 1000 psi | 400 °F % E in 2 in. | 500 °F UTS 1000 psi | 500 °F YS 1000 psi | 500 °F % E in 2 in. | 600 °F UTS 1000 psi | 600 °F YS 1000 psi | 600 °F % E in 2 in. | 700 °F UTS 1000 psi | 700 °F YS 1000 psi | 700 °F % E in 2 in. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HK31A | T6 | Sand casting | 31 | 16 | 6 | 27 | 15 | 12 | 24 | 14 | 17 | 23 | 13 | 19 | 20 | 12 | 22 | 13 | 8 | 26 |
| HZ32A | T5 | Sand casting | 29 | 15 | 6 | 22 | 12 | 23 | 17 | 10 | 33 | 14 | 9 | 39 | 12 | 8 | 38 | 10 | 7 | 29 |
| ZH62A | T5 | Sand casting | 40 | 27 | 8 | 26 | 20 | 24 | 19 | 15 | 28 | 14 | 10 | 30 | — | — | — | — | — | — |
| TZ4 | T5 | Sand casting | 32.4 | 19.0 | 4.5 | — | — | — | — | — | — | — | — | — | — | — | — | — | — | — |
| HM11XA | F | Die casting | 30.2 | 21.2 | 4.3 | — | — | — | 16.8 | 14.6 | 13.5 | — | — | — | 12.4 | 11.1 | 13.6 | 9.0 | 9.0 | 14.5 |

**Typical tensile properties of magnesium-thorium casting alloys are given (in optimum heat-treated condition) at room and elevated temperatures.**

adjacently, giving composition and available forms. Principal alloying elements, in these, are: thorium, zirconium, manganese, and zinc. Identifying designations consist of two letters indicating the alloying elements used in the greatest amount.

| | |
|---|---|
| H—thorium | Z—zinc |
| K—zirconium | M—manganese |

These are arranged in order of decreasing percentages rounded off to whole numbers. Letters (usually A) following rounded-off percentages indicate modifications of the original alloy; an "X" denotes a development alloy.

Currently, most magnesium-thorium alloys exhibit little variation in physical properties. Densities range from 1.75 to 1.87 g/cm³. Coefficients of thermal expansion are very near 14.5 x $10^{-6}$ in./in. per °F, and specific heats are near 0.25 Btu/lb/°F. Thermal conductivity, however, depends on composition and temper.

Magnesium-thorium alloys are fabricated by the same techniques used for other magnesium-base alloys; they are likewise worked at elevated temperatures. Development studies indicate that forging temperatures of 700 and 1000°F can produce sound shapes with good mechanical properties. Extrusion, however, requires higher temperatures and pressures than for conventional alloys; magnesium-thorium alloys are also more difficult to roll into plate and sheet. Sheet stock of HK31A and HM21A alloys have been formed at 650 to 700°F without subsequent loss in strength. Forming methods applicable include drop-hammer forming, press braking, spinning,

| Alloy, Temper Form | Room Temperature | | | | 300 °F | | | | 400 °F | | | | 500 °F | | | | 600 °F | | | | 700 °F | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | UTS 1000 psi | YS(T) 1000 psi | YS(C) 1000 psi | % E in 2 in. | UTS 1000 psi | YS(T) 1000 psi | YS(C) 1000 psi | % E in 2 in. | UTS 1000 psi | YS(T) 1000 psi | YS(C) 1000 psi | % E in 2 in. | UTS 1000 psi | YS(T) 1000 psi | YS(C) 1000 psi | % E in 2 in. | UTS 1000 psi | YS(T) 1000 psi | YS(C) 1000 psi | % E in 2 in. | UTS 1000 psi | YS(T) 1000 psi | YS(C) 1000 psi | % E in 2 in. |
| HK31A—H24 Sheet | 37 | 29 | 23 | 8 | 26 | 23 | 23 | 20 | 24 | 21 | 22 | 21 | 20 | 17 | 20 | 19 | 13 | 7 | 10 | 70 | — | — | — | — |
| HK31A—T5 Forging | 39 | 21 | 23 | 14 | 26 | 21 | — | 23 | 25 | 19 | — | 22 | 21 | 12 | — | 26 | 21 | 14 | — | 24 | 16 | 6 | — | 90 |
| HM21A—T8 Sheet | 34 | 25 | 15 | 10 | 21 | 19 | 15 | 20 | 18 | 17 | 15 | 30 | 16 | 15 | 15 | 25 | 14 | 12 | 13 | 15 | 11 | 8 | 9 | 50 |
| HM21A—T5 Forging | 38 | 23 | 17 | 10 | 23 | 19 | — | 29 | 20 | 16 | — | 29 | 18 | 14 | — | 26 | 17 | 13 | — | 25 | 12 | 9 | — | 45 |
| HM31A—F Extrusion | 42 | 33 | 25 | 10 | 28 | 25 | 24 | 30 | 24 | 32 | 22 | 32 | 21 | 19 | 19 | 25 | 17 | 15 | 15 | 22 | 13 | 11 | — | 35 |
| HZ21—F Extrusion | 36 | 25 | — | 6 | — | — | — | — | 21 | 17 | — | 10 | — | — | — | — | — | — | — | — | — | — | — | — |

(T) tensile. (C) compressive.

**Typical mechanical properties of magnesium-thorium wrought alloys are presented at room and elevated temperatures.**

**Low-temperature tensile-properties are given for two magnesium-thorium alloys.**

| Alloy Designation | Temper | Temperature °F | Ultimate Tensile Strength, 1000 psi | Tensile Yield Strength, 1000 psi | Per Cent Elongation in 2 inches |
|---|---|---|---|---|---|
| HK31A | H24 | 75 | 36.3 | 29.0 | 7.5 |
| | | −65 | 43.3 | 32.0 | 5.0 |
| | | −110 | 42.7 | 30.6 | 4.2 |
| | | −320 | 54.0 | 33.0 | 6.2 |
| HM31A | F | 75 | 40.5 | 36.6 | 13.5 |
| | | −65 | 48.4 | 40.2 | 7.5 |
| | | −110 | 48.3 | 38.6 | 44.5 |
| | | −320 | 57.5 | 44.8 | 5.5 |

## magnesium . . . continued

deep drawing, trapped rubber forming, and hot press and hand forming.

Forming at elevated temperatures has its known advantages. Often, parts can be severely formed in a single operation without intermittent annealing; springback is small at these temperatures, hence, close tolerances are readily obtainable. Machining, joining, and corrosion characteristics of thorium-bearing alloys are similar to most magnesium-base alloys. High feed-rates and deep cuts present no special problems; notch-sensitivity is a factor, therefore, surface flows must be prevented.

### Applications

Magnesium applications in aircraft structures have already gained wide publicity. A number of typical applications have been highlighted in adjoining sketches. There are probably few missiles, operational or under development today, which do not incorporate magnesium-alloy in some form.

The Titan ICBM, and the Thor-Discoverer space research vehicle represent extensive uses of magnesium in missile structures. About 40 per cent of the Titan skin structure incorporates magnesium-thorium sheet and extrusions, amounting to some 2000 lb. Magnesium-thorium sheet is used in four transitional sections of Titan skin as follows: (1) between first-stage fuel and oxidizer tanks; (2) between first and second stages of missile; (3) between second-stage fuel and oxidizer tanks, and (4) between second stage and the nose cone.

Magnesium-thorium extrusions are used for external conduits between fuel and oxidizer tanks in both stages, also for stringers, longerons and hinges. Alloys used are HM21A and HK31A in sheet form, and HM31A extrusions.

Each of the five Discoverer satellites launched to date, incorporated over 600 lb of magnesium-thorium alloys. Total weight of each vehicle ranged from 1300 to 1700 lb. Satellite's skin and fairings are all HM21A-T8 sheet of 0.071 to 0.143-in. thickness, rolled to a tolerance of ±0.002 in. Structural requirements in this case include resistance to aerodynamic heating and temperature reversals (while passing in and out of Earth's shadow), and resistance to compressive buckling. Discoverer satellite also includes HM31A extrusions. HK31A-T6 castings, and forging of HM21A-T5 magnesium-thorium alloy.

◆

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# brazing titanium sandwich

**"best" alloy for honeycomb sandwich face and compatible brazing-alloys selected; quartz-lamp radiant-heat process shows advantages over present techniques**

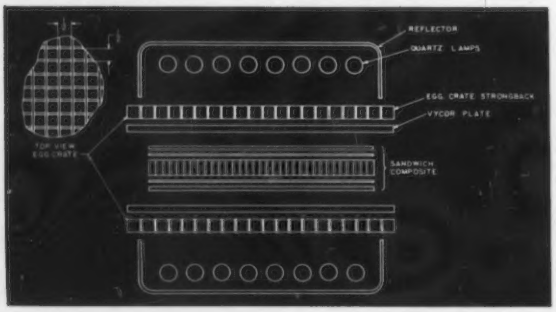
High-strength titanium sheet and foil will probably soon be available in quantity. Anticipating this availability, WADC has funded an investigation of honeycomb sandwich brazing. The investigation covered alloy evaluation for core and face material, study of brazing alloys, process improvement, and structural testing. Importance of process improvement is evidenced by the fact that end-item cost for brazed sandwich is now about $300/sq ft. Metals Research Dept. of Armour Research Foundation, who conducted the brazing study, focused great attention on the quartz-lamp radiant-heat process.

### Advantages of Quartz Lamp Process

The advantages of the quartz-lamp radiant-heat over furnace retort techniques now in use are:

- Good temperature control over a wide range.
- Control over uniformity, or non-uniformity by apparatus design.
- Clean, portable heat source that can be placed within atmosphere chamber. This eliminates need for costly, one-shot retorts.
- Low equipment costs.
- Good possibilities for adapting to continuous production.

**Exploded schematic of equipment used for radiant-heat brazing process. The "egg-crate" strongbacks, and Vycor plates are transparent to radiation and apply flattening pressure. Entire apparatus was placed in an inert atmosphere.**




### Alloy Selection

Nineteen titanium alloys were evaluated as facing sheet. Mallory Sharon's MST Ti-16V-2 ½Al was selected as the material for use in process studies. Republic Steel's RS-140 was selected as standby material.

The Mallory Sharon alloy is one of four in the Department of Defense Titanium Sheet Program. All four were chosen because of high-strength heat-treated condition, and high-formability solution-treated condition. All have good availability, and stability to 800°F. Ti-16V-2 ½AI is different from the group in one important respect. It has a solution temperature of only 1370 to 1400°F, which is very good for allowing selection of low melting brazing alloys.

Seventeen brazing alloys were evaluated. For brazing titanium sheet to pure titanium core at 1500°F, Ag-28Cu-0.2Li and Ag-1.25 Mg-0.2Ni-1Li were best. The former is the stronger of the two. For brazing titanium sheet to stainless core, these two alloys plus Ag-7Cu-0.2Li and Ag-30

Cu-10 Sn were found best. Brazing temperature in the latter case was 1600°F.

### When And How To Braze

For sandwich hardware to possess optimum mechanical properties, heat treat cycles must be closely controlled. This means that the brazing cycle must be accomplished somewhere in the heat treating cycle, without disrupting the optimum sequence.

There are four places this could possibly be done: (1) prior to solution treatment, (2) during solution treatment, (3) prior to aging, (4) during aging.

The last offers most potential advantages, but must be ruled out because there is no brazing alloy which melts at aging temperatures, 900 to 1100°F. This leaves only the possibility of brazing at temperatures common to solution treatment. This factor has a great bearing on choice of materials and processes.

Low solution temperatures are attractive so that low-melting brazing alloys can be used. The use of lower brazing temperatures is important from an economics standpoint, and from a purely metallurgical standpoint. At high temperatures, the brazing filler material sometimes attacks the honeycomb core.

### The Quartz-Lamp Process In Brief

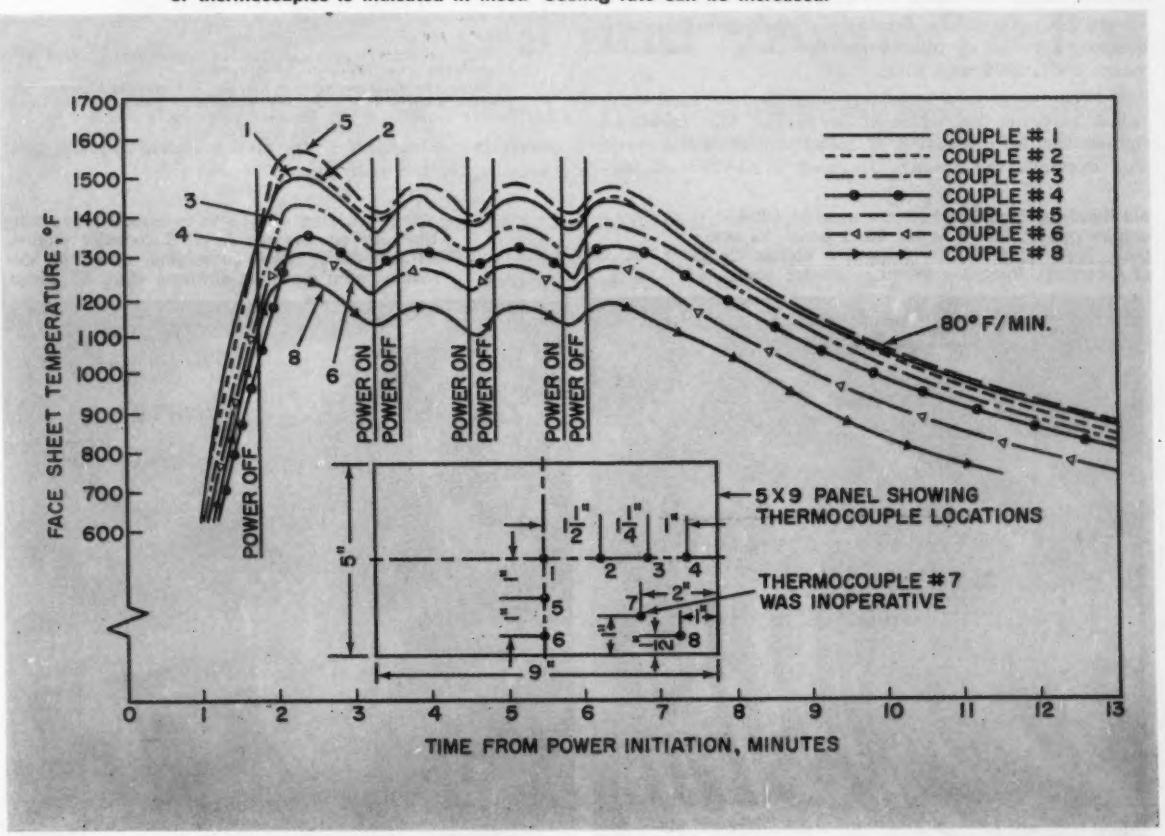
Quartz-lamp radiant-heating studies were conducted with the apparatus shown in the accompanying schematic. Radiation from electrically heated tungsten filaments, and from reflector surfaces, passes through an "egg-crate" support and Vycor plate glass to heat the titanium sandwich.

Just prior to brazing, face sheets were cleaned by dipping in a solution of 30 per cent nitric, 3 per cent hydrofluoric acid for 20 sec. Core was similarly cleaned, except that stainless core required 30-sec dip. Brazing shims were cleaned in the same solution.

Since "bags," or retorts, are not used in this process, pressure was applied mechanically through the "egg-crate," and Vycor plate, to the face sheet. A 15-lb weight was adequate in every case.

Lay up was placed in an enclosure evacuated to a pressure of 0.1 to 0.2 microns. Purified

**Actual time-temperature plot shows thermal gradients during brazing cycle. Position of thermocouples is indicated in inset. Cooling rate can be increased.**



# brazing titanium . . . continued

helium was then admitted to a pressure of 1 atmosphere and allowed to flow at a rate of 28 cfh during brazing.

Typical time-temperature curve is illustrated from actual test run with multiple thermocouples. Power must be switched on and off to maintain heat. This is not uncommon in any thermostat controlled device. Power should be adjusted to give a constant brazing temperature "plateau" for 3 to 6 min. After brazement, power was completely shut off and panel was cooled by radiation and convention. Helium was kept flowing to give a cooling rate of 80°F/min. This rate can be increased.

### Problem Areas

Two components must be considered possible problem areas in adapting the process to production. The "egg-crate" support, and the Vycor glass plate. "Egg-crate" problem is one of attaining adequate strength to transmit uniform pressures when panels reach production size. Vycor reacts slightly with the adjacent titanium skins. The titanium seems to reduce the silica in the Vycor.

Detailed results of mechanical test are available to qualified personnel from WADC. They are encouraging results.

✦

*Based on WADC technical report 58-167, "Brazing Titanium Sandwich Construction," by John F. Rudy, Robert Nechcles, Harry Schwartzbart, Armour Research Foundation of Illinois Institute of Technology.*

# • ABOUT TITANIUM USAGE

On a strength/weight basis it now appears titanium alloys will be the most efficient structural metals for service up to 1000°F until 1968. This is based on the findings of a Defense Metals Information Study.

The use of titanium in engines and airframes, on a per-unit basis, will increase continually throughout the period 1961-1968. Per-unit usage of alternative steels will exceed titanium usage and will exhibit an increasing trend in the early 1960's. Steel usage may stabilize as titanium usage continues to rise in the late 1960's.

Usage estimates, for some of the weapon systems studied, average as follows for the example production years, 1961, 1965, and 1968.

The table is a sweeping simplification of the detailed statistics on which it is based. The tabulated figures can be misleading if taken out of the context. For example, the average included a number of low-performance support and training aircraft systems, especially for the year 1961.

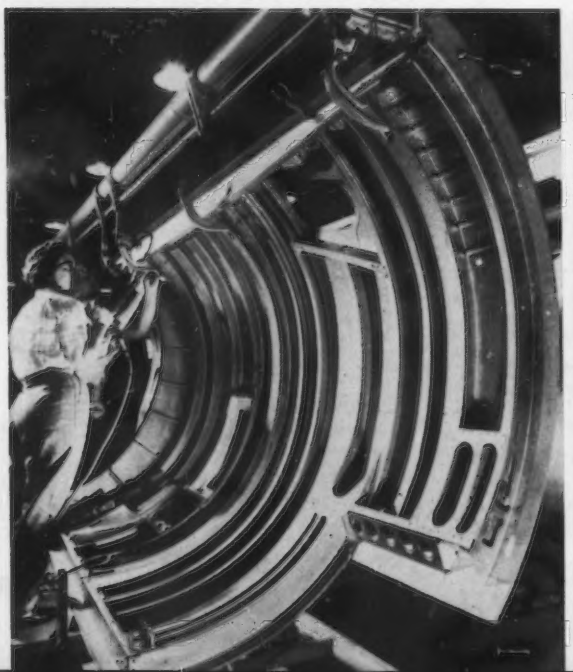
| | Estimated Average Per-Unit Usage, per cent of structure weight | | | | | |
|---|---|---|---|---|---|---|
| | 1961 | | 1965 | | 1968 | |
| | Titanium | Steel** | Titanium | Steel** | Titanium | Steel** |
| Predicted usage | | | | | | |
| Airframes*** | 2 | 16 | 8 | 45 | 9 | 39 |
| Engines | 4 | 24 | 8 | 24 | 9 | 24 |
| Possible usage | | | | | | |
| Airframes*** | 8 | 15 | 34 | 30 | 24 | 25 |
| Engines | 8 | 22 | 10 | 22 | 11 | 22 |

* *1400°F for short-time applications.*

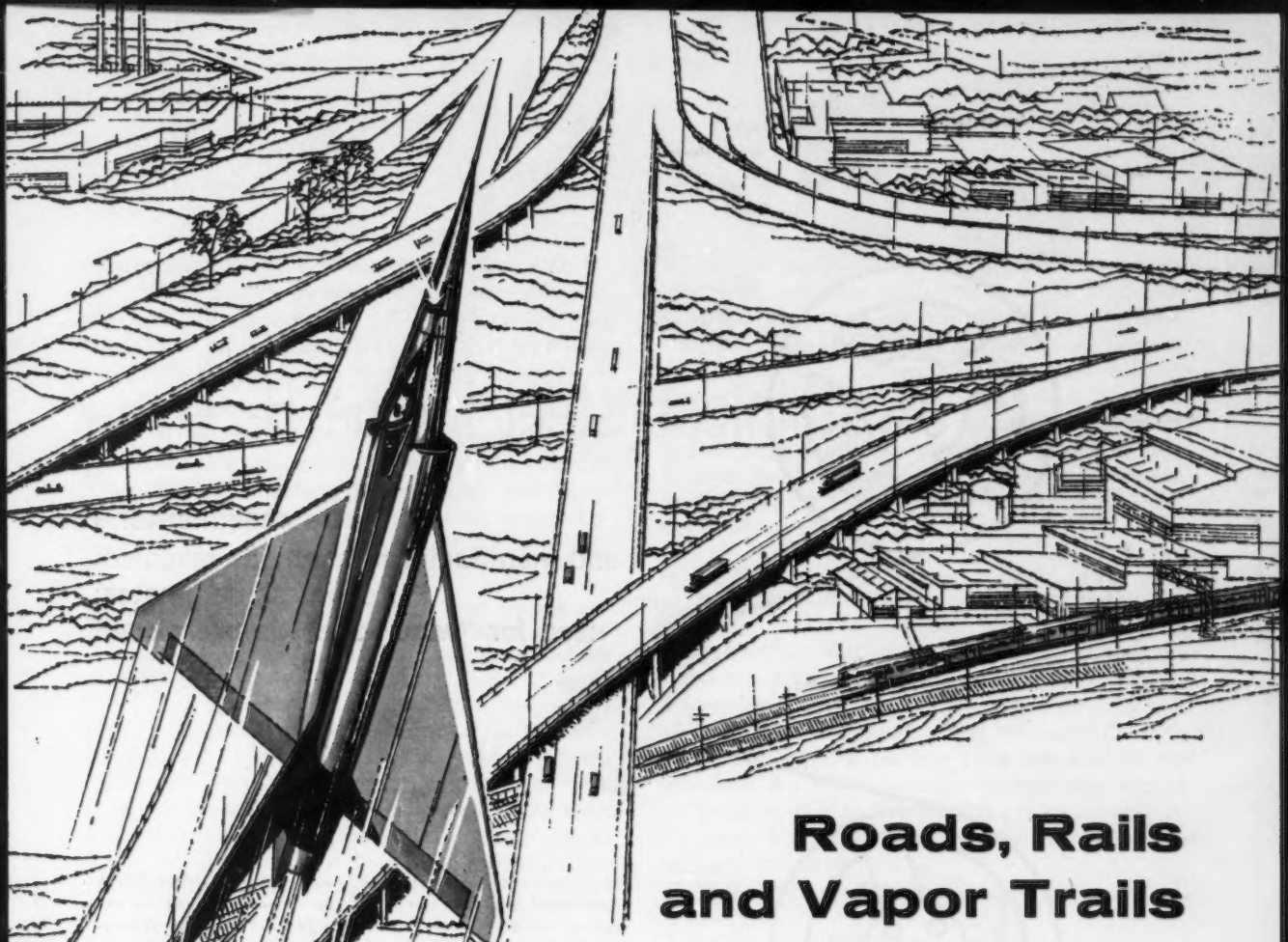
** *"Steel" includes only steel used in applications where it is considered an alternative for titanium.*

*** *Casings for solid-propellant motors are included in the airframes with which they are integral. Tankage for liquid rocket propellants are likewise airframe.*

**Six hundred lb of titanium are used in DC-8 engine pods. Shown is an 80-lb panel for one pod. Material is Ti-75A (Titanium Metals Corp. of America). Ryan-San Diego fabricates pods.**



**Weight saving of 443 lb is effected by using titanium compressor in J-75 turbojet engine. Pratt & Whitney says cumulative effect of this saving could make an airframe 4000 lb lighter.**



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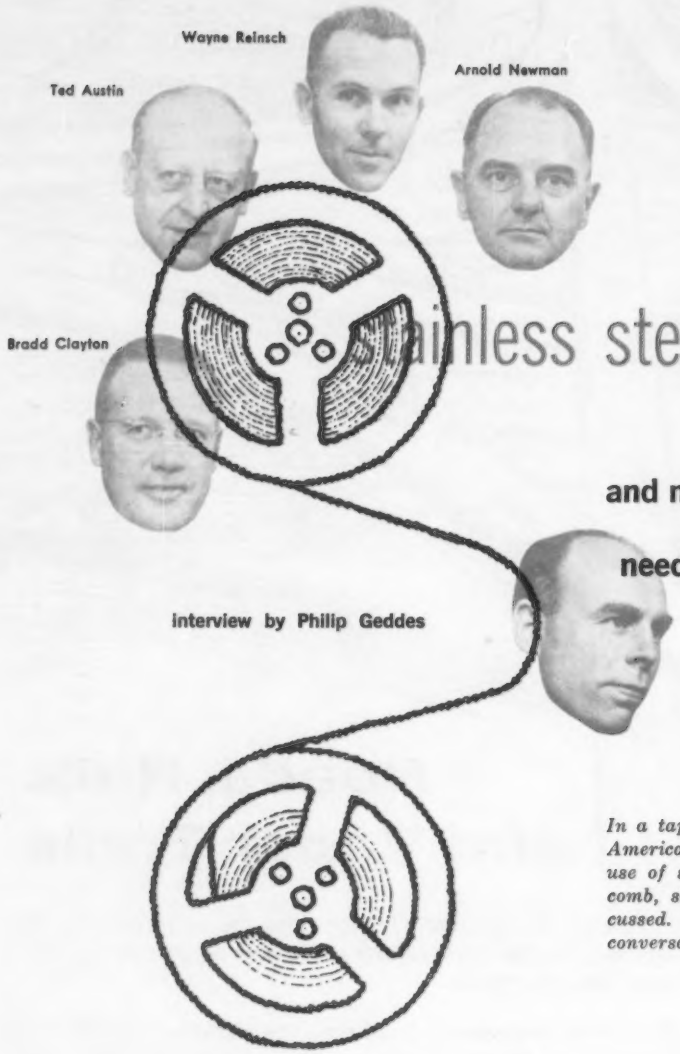


# stainless steel in the B-70

## design criteria and manufacturing methods revealed; PH stainless dominates; need for "wide" sheet is overplayed

interview by Philip Geddes

*In a tape-recorded interview, four engineers from North American Aviation Corp. set the record straight on the use of stainless steel in U. S.'s Mach-3 bomber. Honeycomb, sheet, forgings, extrusions, and castings are discussed. Some penetrating facts are revealed in casual conversation.*

**Q. Will B-70 utilize more stainless steel than any aircraft or bomber in the past?**

**A.** It will. The bombers in the past have been primarily aluminum aircraft. We're in a temperature range now where aluminum is out of the question.

**Q. What temperature range?**

**A.** It varies considerably over the airplane . . . let's say up to 1200°F.

**Q. Is honeycomb structure used, and if so, why?**

**A.** Due to the high density of steels and the lower load requirements in terms of density, certain (optimum) thicknesses arise. You have to stabilize the material to get it into an efficient structural range. This is what forces us into a sandwich type structure, and a honeycomb sandwich is used on the B-70.

**Q. Does the increased use of stainless in the B-70 indicate a trend towards more stainless steel in future aircraft?**

**A.** Not entirely . . . it's hard to generalize. Beryllium is coming into the picture and it will be quite a strong contender over 1000°F . . . but stainless looks like it's going to be the clincher for the immediate business.

**Q. How about stainless in commercial aircraft?**

**A.** The aircraft of the next generation, the immediate next generation, will probably be stainless steel . . . but I feel the number of units that are going to be produced will be low because of the economy factor.

**Q. What type of stainless steel will be used?**

**A.** The types used in the sandwich and also in the sheet metal construction are the PH steels

◄ Circle 8 on Inquiry Card

for the most part . . . strength is around 200,000 psi. They've been chosen for this strength and for corrosion resistance. Although there are steels that have higher strengths, this corrosion resistance characteristic is important.

**Q. What specific alloys are in use?**

**A.** PH 15-7 MO is one of (Armco's) better grades for this application, as well as the 350 and 355 alloys of Alleghany-Ludlum. We call these the semi-austenitic precipitation-hardening corrosion-resistant steels. We (NAA) group these three together in the same family.

**Q. Convair people have mentioned that gauges are quite thin on Atlas. Are still thinner gauges used in the B-70? Are new welding techniques employed?**

**A.** The Atlas is a resistance-welded structure—(Convair) can use a different type of material than we . . . So where they're using the hard-rolled 300 series materials, we're using the heat treatable types. They are heat-treated along with the sandwich brazing sequence in many cases. Sheet thicknesses down to around 0.006 in. are required for our applications, and they range upward. We're also using foil in thicknesses down to about one-thousandths thick . . . thickness tolerance becomes a real important issue on total weight. Thickness isn't any more important, or significant, than the tolerance that goes with it. So here is where the American Iron & Steel Institute would take a real interest in this product. Before anyone offers a product they should have to meet the thickness and tolerance requirements, or they should have a way to reach them after the product is rolled—one or the other.

**Q. Do these applications put a strain on the commercial tolerances, and width capacities?**

**A.** It's quite common in this industry to talk about one-half of A.I.S.I. tolerances, and the mills are quite capable of producing this without a premium cost. This is a start but there is still the tolerance of $\pm 0.001$. That brings us down to something quite a bit less than one-half of the standard A.I.S.I. tolerance. We require widths up to 12 ft. We're now able to get 48-in. widths. So from 48 in. to 12 ft, represents quite a change in width requirements.

*continued on next page*

**NAA engineers (left to right) Clayton, Reinsch, Newman, and Austin examine some of the non-structural stainless steel parts in B-70. Flexible hose for 4000 psi-400°F hydraulic system is one area still under vigorous development. Structural applications are mostly welded-brazed honeycomb sandwich.**

**Q. So what's the answer—a giant new family of Zendzimir mills?**

**A.** This has been proposed as a possibility. It sounds like a good one, if the tolerances can be made. The other one is to weld narrow sheets together in multiples, until you achieve the 12 ft width. This is the matter of economics again. There isn't too much point in making precision rolling equipment to get a close tolerance, which will be ground anyway. (Interruption.) I think we ought to point out that this large sheet requirement shouldn't be taken too seriously. Everybody seems to be getting excited about the necessity. It's something that can be worked around.

**Q. In other words, it doesn't justify a crash program.**

**A.** This is exactly what I'm trying to put across.

**Q. Is there anything you would want to say about manufacturing?**

**A.** I might say the materials we are using require complicated processing. The heat treatment has to be compatible with our brazing cycle. The materials have very specialized requirements which are way over and above what we have worked to in the past. We have to be able to process parts and get aerodynamic surfaces, after heat treatment, of about 0.002 in. This makes heat-treat distortion and other processing variables very critical. It requires very tight controls.

**Q. What are the manufacturing processes?**

**A.** They are principally welding. We are using a lot more welding in our fabrication than we ever have before, so brazing and welding have come to a new importance.

**Q. Are any of the skins tapered?**

**A.** A great many will require tapering.

**Q. How are they tapered?**

**A.** I don't think this is restricted. One of our latest developments in obtaining tapers, both single and multiple, is by belt machining. Simply a sandpapering operation. Another way is by chemical milling, by going through a solution at variable rates. So we've just about eliminated the standard milling operation because of the close tolerances required. Many of our applications require several tapers in the same skin; and they're not always parallel to the direction of rolling. We go off on tapers that will cut "catty wompus" across the sheet rather than with the sheet. We can whittle it out cheaper than we could buy it rolled.

**Q. Are there any stainless steel extrusions in the B-70?**

**A.** I would say we'd like to have extrusions.

**Q. What specific problems do you face in obtaining extrusions?**

**A.** The only point in going to extrusions is to get a shape or to improve mechanical properties. Some of these materials, apparently in the extrusion range, have a hot-short characteristic, this results in surface tearing or bad surface. Poor tolerance arises from die wash, the temperatures, and the abrasiveness of the material. So if we can't get the tolerances and the surface we want, extrusions start to lose a lot of their appeal right from the beginning. The second point, if we can improve the mechanical properties, then some of these other things might be worth living with or trying to overcome. We think, in some of these PH steels, this is true.

**Q. What is the extent of extrusion use?**

**A.** I would say it's a difference from nothing in the past to a substantial amount.

**Q. What is the extent of the use of forging?**

**A.** The fact that we can weld steels, and heat treat them, makes it possible for us to think in terms of welding, which are entirely new. The forging requirement, as we would think of it in terms of aluminum, like large massive forged spars, bulkheads and so forth, is not a requirement. However, if we could get the large forging economically, with the basic material tolerance and with the needed strength, there would be a slight advantage over the weldments. Our weld assemblies, even with subsequent heat treat, suffer a strength reduction across the weld.

**Q. How about structural castings in stainless?**

**A.** So far, strength values with castings haven't come up to what they should be from a weight standpoint. So, weight being all-important, we just can't afford to go the casting route.

✦

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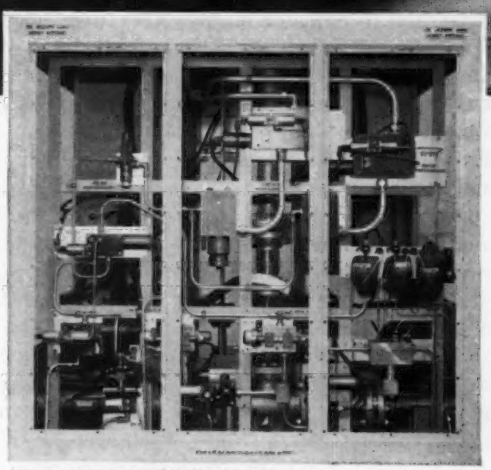
# WILL IT WORK UP HERE?



Vinson valves are used in the dynamic checkout unit built by Consolidated Systems Corporation for use in the Atlas missile program.

Behavior of helium and nitrogen valves can be predicted if you simulate conditions and pre-test on the ground. Pressure regulators, relief valves, and flow controls must be better than the systems they are checking. It takes knowledge gleaned from experience to design ground support units that guarantee expected behavior of a missile *up here.*

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# new grip on honeycomb

## hard, water-soluble surface protective simplifies honeycomb chucking at Aeronca

The basic structure of honeycomb precludes the use of usual holding devices during machining. Structural component manufacturers have been experimenting with a variety of quick-hardening liquids to hold the material in place. To date each has shown some limitation. Most are hard to remove after machining, some let go during machining, and some are injurious to the core material.

### Serendipity?

At Aeronca Mfg. Corp., a kind of serendipity played the starring role in helping solve some of these problems. A process engineer working with a Zincilate surface protecting agent noted the material was water soluble, hard, and compatible with either steel or aluminum. He wondered whether it might also be used to hold honeycomb in place during machining. The machining department investigated. Tests were satisfactory with stainless AM-350, AM-355, 17-7 PH, and PH 15-7 Mo. A 1/16-in. coating was adequate, setting time was 15 to 30 min. As a result, Zincilate WST-200 is being used on regular production runs.

Zincilate WST-100, originally intended as a surface protectant, is spread on steel plate to hold-down honeycomb for machining. Weights are not used on core, merely hold frame in place until vacuum is applied.

Honeycomb section is placed in steel frame. Rubber blanket is placed over frame and vacuum is applied. No heat is necessary.

Stainless steel core up to 3 in. thick and 115 x 65 in, have been held down securely. Milling machine feed on ⅝ in. sections has been stepped up from 26 to 44 in./min. Setting time, which formerly ranged from 4 to 8 hr, has been reduced to 30 min. WST-200 is removed in a 15-min hot-water dip, other coatings used by Aeronca required hours.

### Process Details

No special equipment is used in applying the honeycomb hold-down coating. Aluminum frames, in sizes and shapes to match honeycomb sections, are placed on steel plates. Six 15 x 20-in. sections are worked at a time; larger sections are worked in pairs or singly. A 1/16-in. coating of WST-200 is poured and spread upon the steel plate inside each frame. The honeycomb is then fitted into the frame and covered with Osnaburg cloth. A rubber blanket is then rolled over the cloth and is pulled down snugly over frames and honeycomb by means of a vacuum. The cloth is used to protect the blanket from cuts and punctures, and to prevent the vacuum pressure from pulling the blanket tight enough to bend or distort the cells of the honeycomb. No weights are used on the core.

When the coating has set firmly, the complete unit, now a single piece — plate, frame and honeycomb — is ready for machining. One man handles the entire operation, from the pouring of the hold-down coating to the finished machining. While one set of honeycomb sections is hardening, he machines the sections previously prepared.

Following the machining process, the units are removed to the cleaning department where they are dipped for 15 min. into a tank of water heated to 212°F. The honeycomb is then removed from the plate and frame and is completely clean and free of all evidence of the hold-down coating.

✦

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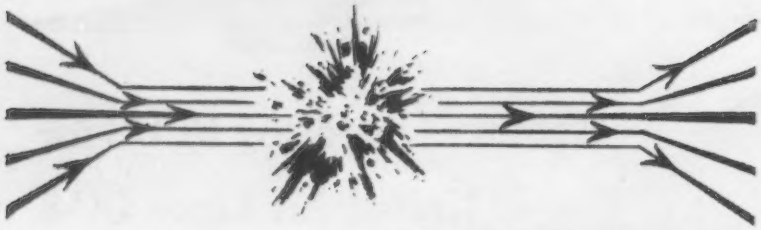
# light, mobile weapons



## Army shows missiles and support equipment geared to mass-attack-disperse tactics

Vertol's Chinook (107 prototype shown) could become backbone of Army's mobility concept for weapons like Little John, Sergeant and Honest John. Weapon, support equipment, and crew for Little John are no strain for one Chinook.

Honest John is a larger weapon, 27 ft long. Can deliver atomic warhead. Entire ground support equipment cannot be carried in helicopter. No electronic controls are used.

Army opened the gates at Aberdeen Proving Grounds last month to display the weapons and ground support equipment it will use to effect its new hit-and-run tactics. About seven thousand members of American Ordnance Assoc. (AOA) saw the demonstrations.

Whole Army approach is now geared around keeping men and equipment dispersed, except during actual attack. At the appointed time forces will rapidly mass, attack, then rapidly disperse again. This calls for a high degree of mobility, and weapons which lend themselves to speedy assembly and disassembly.

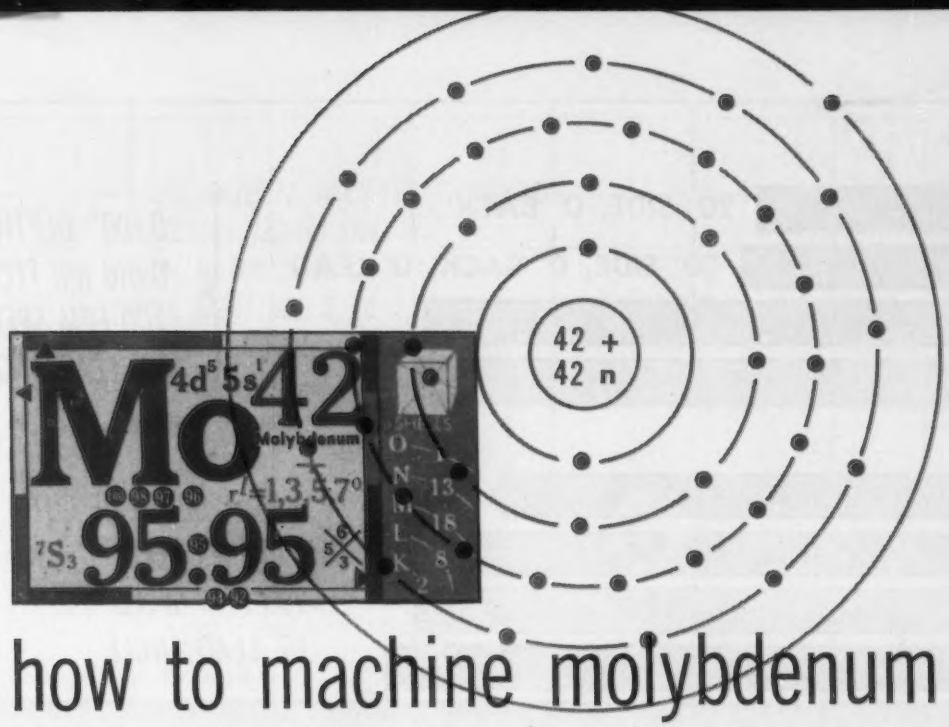
Some of the highlights of the AOA demonstration were: (1) the complete assembly of a Sergeant missile on its launch pad in about 10 min., (2) displays of air mobility of Little John using a prototype of Army's new turbine helicopter, the Vertol Chinook, (3) "ripple" firings from various small-rocket launchers.

Little John was landed, set up, fired and crew was ready for evacuation in less than 12 min.

◆

Redeye, a surface-to-air missile, is is man-transportable. The 20-lb weapon has rocket motor, explosive and guidance in its 3-in. diam. Mission is to destroy strafing and low-level bombing aircraft.

"MAW" is an anti-tank weapon. Fires a 9-lb shaped charge about 500 yds. Weapon is 4 ft long and weighs about 35 lb. It is often referred to as the 90mm recoilless rifle.




# how to machine molybdenum

## quality of chips can mean economic success or failure; Carboloy Grades 44A and 883 good tool materials, tool geometry with 20 to 25-deg side-rake essential

by **H. J. Siekmann**, market development & research
and **L. A. Sowinski**, machinability engineer,
Metallurgical Products Dept., General Electric Co.

Ten years ago the uses for molybdenum were limited. It was used as an additive or alloying agent for high strength steels. The pure metal was found rarely in anything but the electric and electronic industries . . . and even this was molybdenum metal produced primarily by powder metallurgy.

Industry has since learned to produce reasonably good sized billets of molybdenum; but, barely in time to meet the ever-increasing need for the metal in high performance aircraft and missiles. Its physical characteristics make it especially valuable for these applications. Melting point is 4730°F with good hardness at elevated temperatures.

Machining techniques of this refractory material, however, have not kept pace.

To assist in finding easier and better ways to machine molybdenum, a test program was initiated at Metallurgical Products Dept. of the General Electric Co. Original thesis was that present machining practices could be greatly improved with properly designed and used cemented carbide tooling.

### Chips Can Spell Economic Success or Failure

One factor that had to be faced immediately was the high cost of the metal itself versus the varying scrap value of the chips.

Pure arc-cast molybdenum, depending upon billet size and quantities ordered, runs from 12 to 15 dollars per pound. Standard alloys of 0.5 per cent titanium run from 13 to 16 dollars per pound. Chips of high purity can be remelted directly in the arc-casting furnace in quantities up to 30 per cent of total melt. This results in considerable savings over the pure metal. Hence, chips are of sufficient value to form an important part of any machining study.

The value of contaminated chips is far less. In a large machining program chip contamination can make the difference between a profitable operation and economic failure. This contamination-category would include chips mixed with other metals or rubbish, and chips uncleaned of cutting fluid or chips oxidized because of excessive heat developed during machining.

Preliminary investigations indicated that the conventional cemented carbide tool geometries—even when applied with reasonable speeds

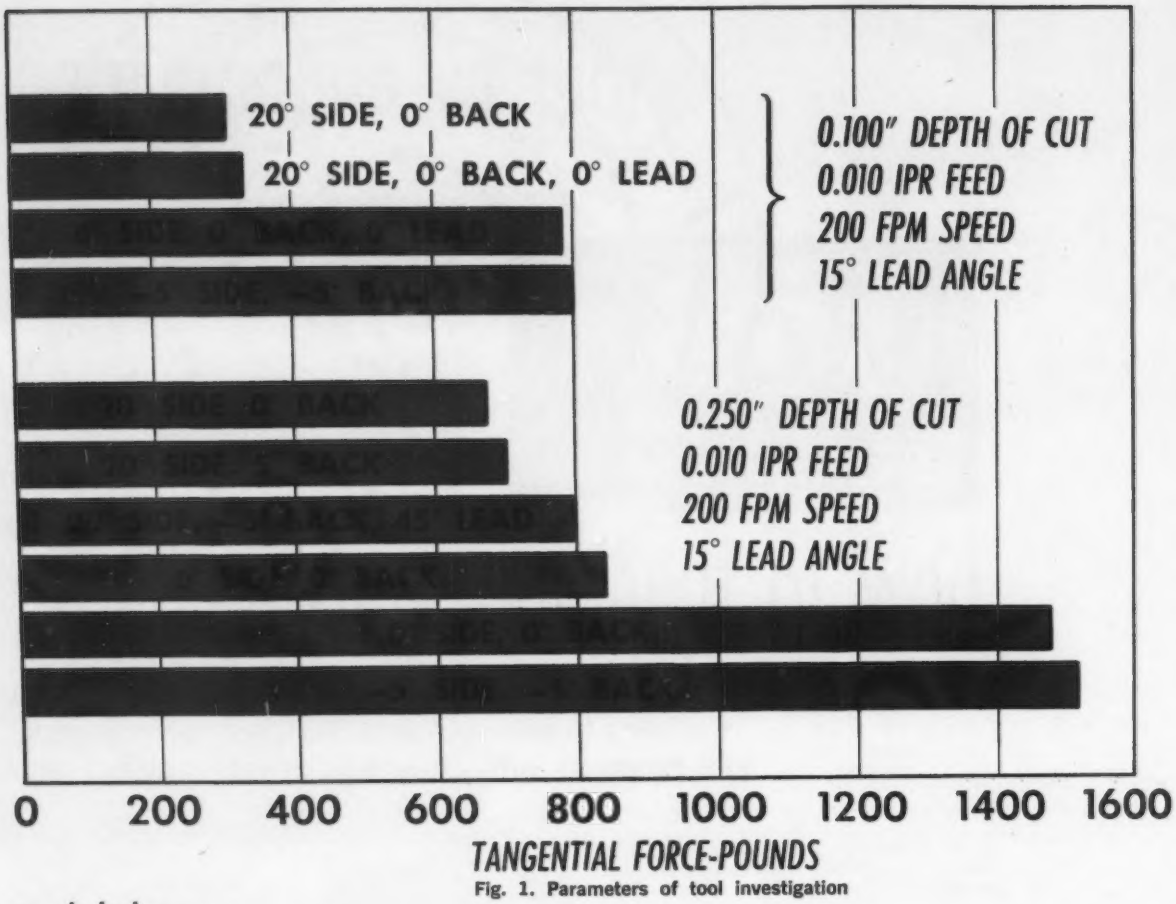
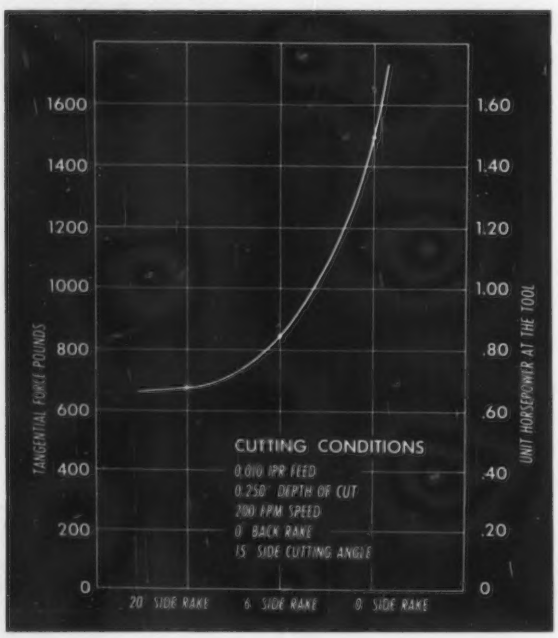



Fig. 1. Parameters of tool investigation

## molybdenum . . . continued

Fig. 2. Effect of side-rake on tangential forces and unit horsepower at the tool.




and feeds—resulted in semiworthless oxidized chips. All the previously reported machining evaluations stamped the steel-cutting grades of carbide as being completely unsatisfactory for machining molybdenum and its alloys. Data obtained with a straight tungsten carbide-cobalt material indicated that the harder, more wear-resistant grades of cemented carbides provided an exasperating and unpredictably short tool life.

### Why Tool Life Is Short

It was suspected that a good portion of this short tool life was due not so much to the abrasive qualities of molybdenum, as to minute chipping of the cutting edge. This was confirmed almost at once in the first stage of our machining investigation.

This minute chipping of the cutting edge, in turn, was caused by excessive buildup and subsequent breakaway of tiny cutting particles of the cutting edge. Where this buildup was minimized or eliminated by manipulation of tool ge-

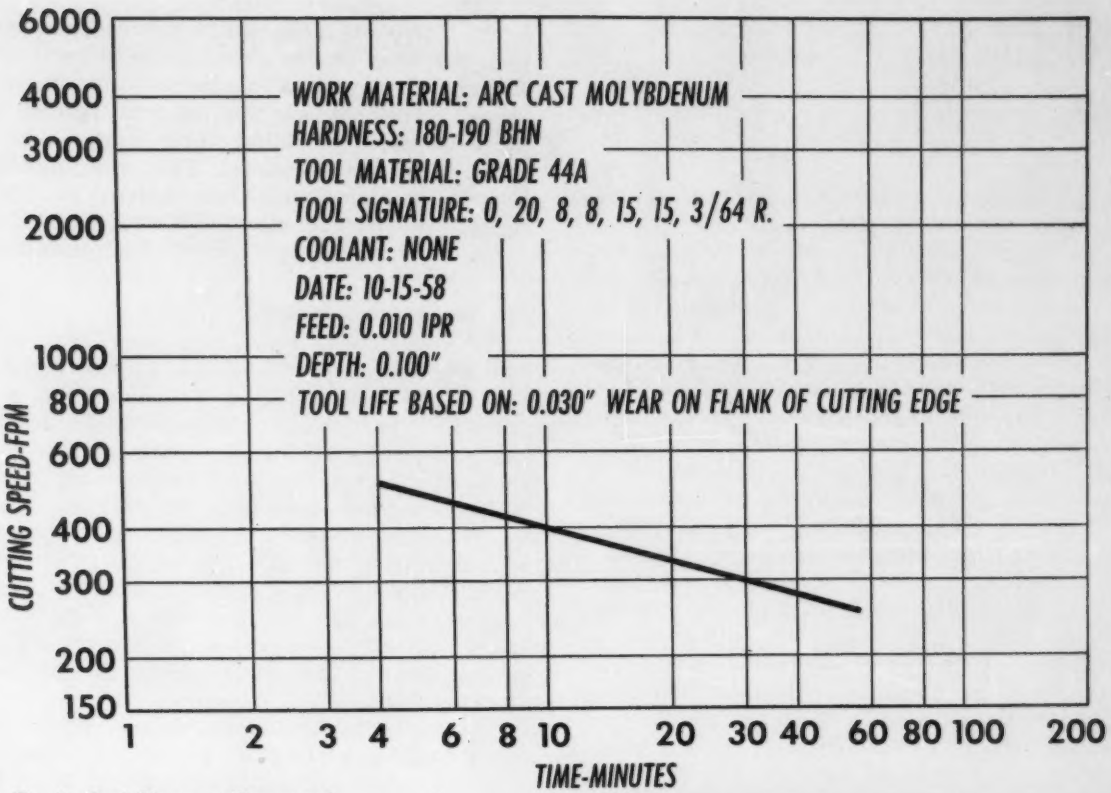



Fig. 3. Tool life vs. cutting speed

Table I. Average surface finish at various speeds using Carboloy 44-A tools.

| SPEED f.p.m | AVERAGE SURFACE FINISH RMS |
|---|---|
| 25 | 230 |
| 50 | 220 |
| 100 | 155 |
| 200 | 140 |
| 400 | 135 |

ometries, wear did not appear to be a major problem. Good tool life was obtained at speeds as high as 600 fpm. (see "how to machine these HT alloys", May 1959).

Since relatively poor chip flow was experienced in both the more conventional tool geometries having either negative back or side rakes, and the standard geometries of brazed tools (0 deg back rake and 6 deg positive side rake), it was a natural step to investigate and measure the effect of cutting forces on these tool geometries.

A bar graph of this investigational sector is plotted in Fig. 1. It is apparent that tool geometries of higher positive rake result in more efficient chip flow. This reduces tangential cutting forces (or vertical component) by 50 per cent or even more.

In Fig. 2 is shown the effect of side rake angle on both tangential force and unit horsepower (hp/cu/min). Study of the two charts shows that increasing positive side rake has a

Table II. Variations in chip thickness at different speeds with 0.005 ipr feed, and 0.250 in. depth of cut.

| SPEED fpm | CHIP THICKNESS |
|---|---|
| 50 | .019 – .021 |
| 100 | .017 – .019 |
| 200 | .016 – .019 |
| 300 | .015 – .020 |
| 400 | .009 – .014 |
| 600 | .007 – .010 |

significant effect on forces and horsepower required to machine molybdenum.

The arc-cast billets used in these machining tests were 180-185 BHN, with billet size 8⅜ in. diam x 20 in. long, and 8 in. diam x 20 in. long. The two billets were composed of a standard 0.5 per cent titanium alloy, while the third billet —pure molybdenum—had a 12-in. diam and 7-in. length. Experiments did not reflect any perceptible machining differences between the 0.5 per cent titanium alloy and the pure molybdenum.

In conventional machining of non-ferrous materials or even the hardest steels, buildup on the cutting edge can be decreased and sometimes eliminated by increasing the cutting speed. In these tests of machining molybdenum, however, buildup on the cutting edge was still present at cutting speeds as high as 700 fpm. This was true even though the thickness of the chip went down as cutting speeds went up. With this buildup continually present, it was extremely difficult to obtain an honest picture of tool wear free of minute chipping.

### Less Heat, Less Oxidation

In metal cutting, 95 to 98 per cent of the machine's horsepower is converted into heat at the cutting edge. In machining molybdenum with high positive rake tools less hp/cu/in of metal removed is used. This reduces the amount of chip oxidation by heat. Using these geometries, excessive oxidation was not encountered until speeds reached 500 to 600 fpm, with feeds through the range of 0.005 to 0.010 ipr.

Heat-oxidation tendencies were further reduced by using an air blast on the chip and cutting edge. With or without the air blast, the heavier cross-section chips could not be allowed to accumulate in the machine tool's bed. Heat retained and insulated in the center of the pile of chips was enough to oxidize the chips to deep purple. This was eliminated by adjusting the air blast to carry chips away from the cutting edge, scattering them widely over the chip pan. With better air blast cooling, there also appeared to be some reduction in the effect of the buildup causing minute chipping of the cutting edge.

As the cutting speed was increased the surface finish of the molybdenum improved (Table II). At the higher cutting speeds, feasible with cemented carbide cutting tools, the chip tended to separate from the billet in straight sections 2 to 4-in. long.

There was no hazard for the machine operator, but when attempts were made to break the straight chip with a mechanical chipbreaker, enough additional heat was fed into the chip to cause excessive oxidation. With lighter cuts a chipbreaker was successful. This was probably because the higher chip cross-sectional area per cu/in of molybdenum removed allowed air-cooling of the chip fast enough to prevent heat oxidation.

### Recommendations In Brief

Recommendations, boiled down, are for a tool geometry having a lead or side angle cutting edge of 15 deg. A higher lead angle was not found to be particularly advantageous. Back rake angles neutral at 0 deg or slightly positive did not seem too critical, but side rake angles from 20 to 25 deg are considered absolutely essential.

In feed ranges from 0.005 in. to 0.010 ipr, a tough grade of straight tungsten carbide/cobalt tool material like Carboloy Grade 44A was most successful. Lighter finishing operations with longer tool life were best accomplished with a general purpose straight tungsten carbide like Carboloy Grade 883.

Honing is highly desirable. All cutting tool edges should be honed at about 45 deg to the rake angles to produce a cutting edge flat of 0.003 to 0.005 in. The relief angles should be 7 deg and the nose radii between 1/32 and 1/16 in.

Chip cooling should be done with an air blast and—as mentioned before—attention should be paid to agitating or distributing chips in the chip pan to prevent an accumulation of heat soak in a chip pile. (No experiments were made with either liquid or carbon dioxide coolants. Carbon dioxide is usually uneconomical, and liquid coolants would reintroduce the problem of chip contamination which was a basic part of our investigation.)

It is possible to draw a tool lifeline indicating a relationship between cutting speeds and the resultant tool life that can normally be expected (Fig. 3). Starting cutting speeds should be in the general neighborhood of 300 fpm, with increases up to 500 fpm for lighter feeds and depths of cut.

As experience with machining molybdenum accumulates, there should not be substantially great variation from the data so far obtained.

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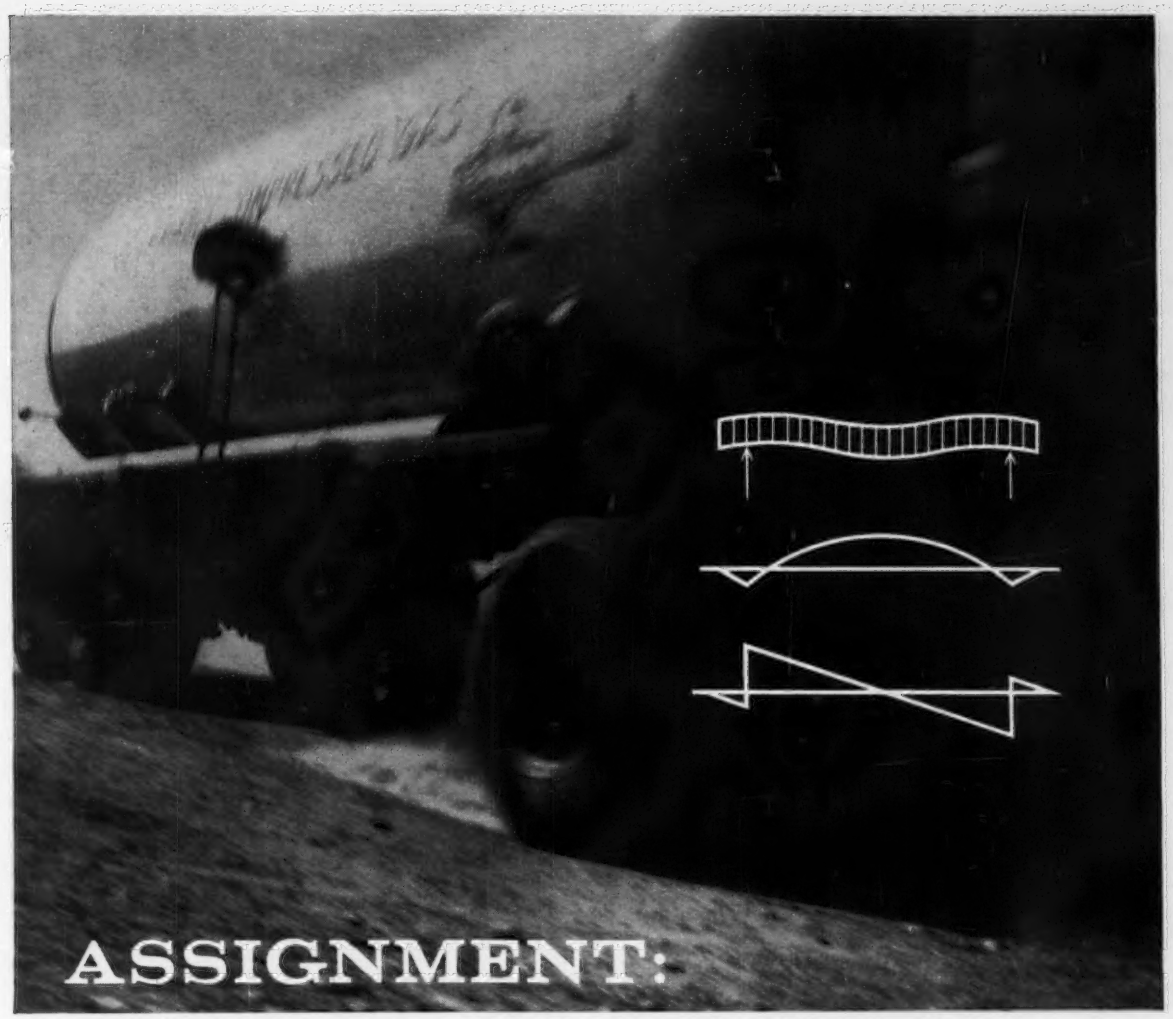


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Master model (right) made of standard tooling resin is shown with honeycomb core contoured by new chemical milling technique.

# chemical milling honeycomb

## contouring core material with etchants may cut costs as much as 55 per cent; process available to "Chem-Mill sub licensees"

by Philip Geddes

A new chemical milling technique for shaping honeycomb core promises savings of time and money in sandwich construction.

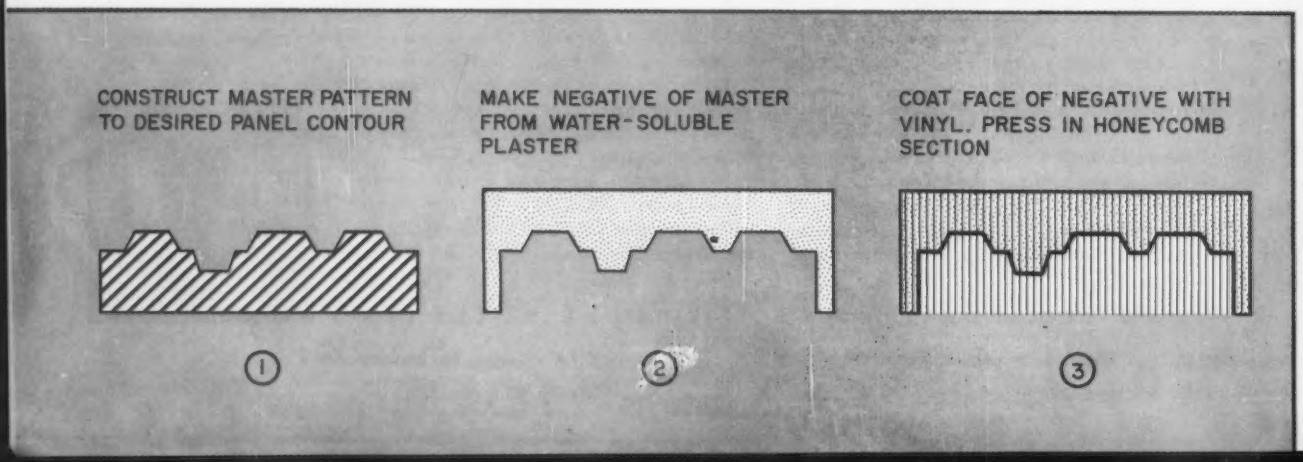
Until now, core shaping has been done by a variety of cutting techniques. Where deeply contoured recesses could be cut out economically, the core was often crushed.

The Norair Div. of Northrop Corp. worked 18 months in developing the chemical milling process. Findings were then turned over to the Chem-Mill division of Turco Products for refinement, and study of production procedures.

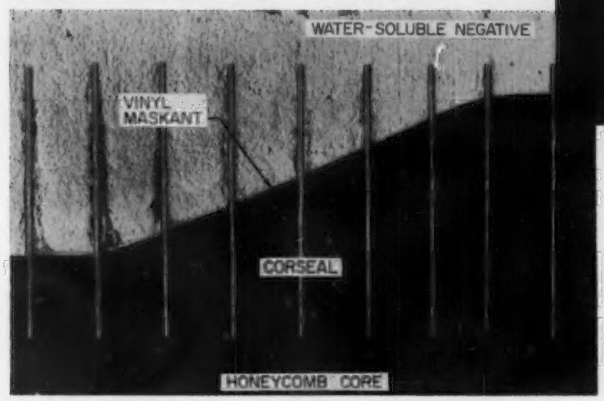
### Tolerances and Cost

Tests indicate no change in the physical properties of the core as a result of the chemical etching action. Dimensional tolerances on core, processed by what will be standard production methods, were easily held to 0.005 in. Tolerances on aluminum parts can be tightened to 0.003 in. and on steel to 0.002 in. with some extra precautions. Naturally, tighter tolerances increase costs. Materials worked on include 5052, 3002 aluminum alloys, and 15-7, 17-7 stainless steels.

Norair made a cost comparison study on a test section of ¾-in. thick aluminum core, 16 in. wide and 36 in. long. It was contoured to various thicknesses from 30 to 67 mils. Some areas were feathered to a sharp edge. An identical test piece was made by well-known machining methods. The accompanying table shows the savings inherent in chemical milling. All operations common to both specimens, such as edge trimming, are not considered in the cost comparisons.


CONSTRUCT MASTER PATTERN TO DESIRED PANEL CONTOUR
MAKE NEGATIVE OF MASTER FROM WATER-SOLUBLE PLASTER
COAT FACE OF NEGATIVE WITH VINYL. PRESS IN HONEYCOMB SECTION
1
2
3

Cross-section of actual layup shows relationship of all materials prior to dissolving water-soluble negative.



After panel is Chem-Milled, Corseal can be peeled away from honeycomb. Dressing the core with fine emery is sometimes necessary to remove maskant.

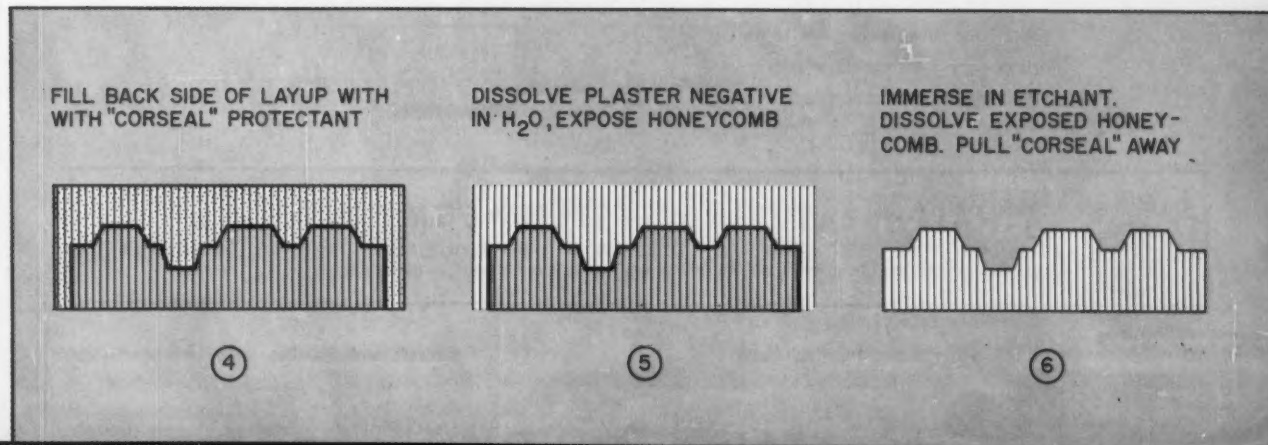
COST COMPARISON

| METHOD | TOTAL TOOLING COST | TOTAL COMPARATIVE UNIT COST | | | | |
|---|---|---|---|---|---|---|
| | | Total Quantity | 10 | 100 | 500 | 1000 |
| | | Release Quantity | 5 | 10 | 25 | 50 |
| Chem-Milled | $800.00 | | $280 | $133 | $93 | $83 |
| Machined & Crushed | $3500.00 | | $619 | $208 | $137 | $120 |

Under "Total Comparative Unit Cost" the projected figures show that a quantity production lot of 1,000 units, in release quantities of 50 at a time, would cost approximately 31 per cent less per piece if chemically milled. Much more significant savings are seen in low quantity production where high tooling costs of machining must be absorbed in the low total output. In the case where a total quantity of ten parts was required, savings increased to 55 per cent/unit, compared with the machined price. Assuming that the Norair study was basically realistic when applied to production, the cost advantages in using an etching process on honeycomb core will insure wide, rapid, adoption of the process.

### Licensing and Royalties

Northrop holds a "sharing type" sublicense from Turco Products to use the Chem-Mill process. Under provisions of the agreement the process will be made available to all sub-licensees who have agreed to participate in the sharing of chemical milling inventions. "Chem-Mill royalties fees, based on the use of chemicals in the process, will remain the same as for sharing sublicensees." ✦


FILL BACK SIDE OF LAYUP WITH WITH "CORSEAL" PROTECTANT
DISSOLVE PLASTER NEGATIVE IN $H_2O$, EXPOSE HONEYCOMB
IMMERSE IN ETCHANT. DISSOLVE EXPOSED HONEYCOMB. PULL "CORSEAL" AWAY
4
5
6

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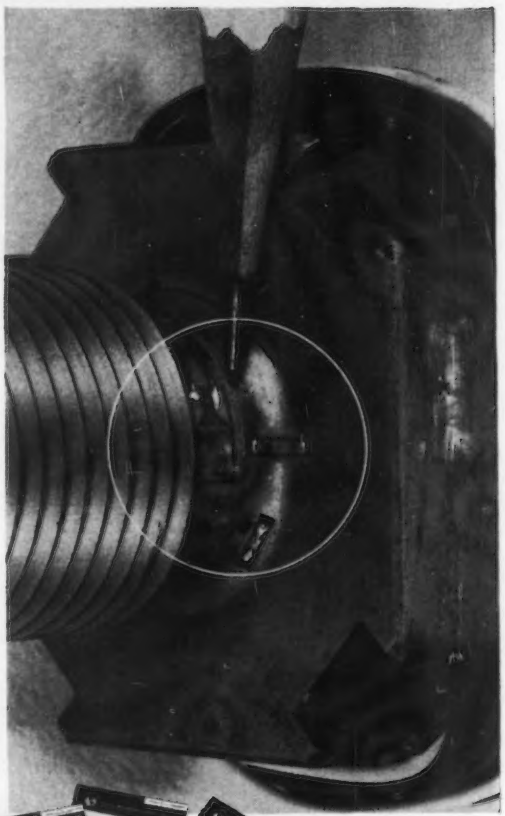

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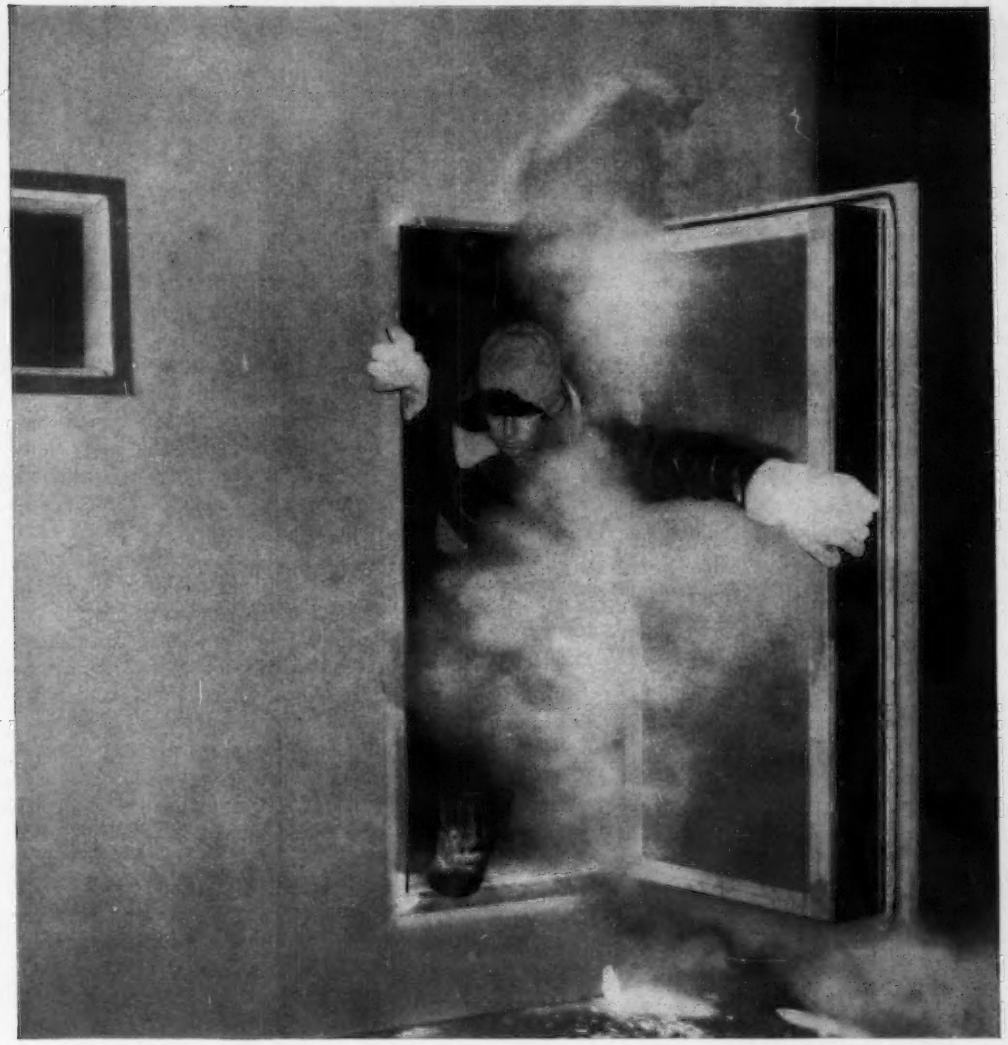

Partial view of a 10′ x 10′ x 35′ low temperature test chamber built by the Mantec Division of Wyle Manufacturing Corp., El Segundo, California. Bulk liquid PURECO $CO_2$ can bring the interior down to −110° F. in minutes.

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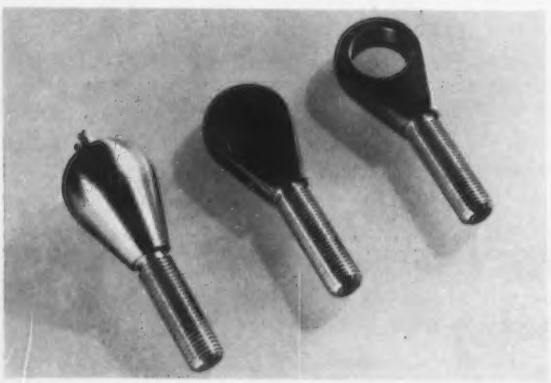
# switch to stainless cuts cost of small hardware

Switching to costlier material to cut production costs of missile hardware, sounds contradictory. It is, however, what took place at Perfecting Service Co., Charlotte, N. C., manufacturer of precision metal products. The company is making special eye-bolts for Douglas Aircraft Co.

Originally, these parts were produced from one-inch, round, AISI 4130 heat-treated steel of 125,000 to 145,000 psi tensile strength; an automatic screw machine was used. However, machining of the steel on such high-speed equipment soon proved troublesome; tolerances on a 3/8-24 UNF-3A thread could not be held, nor could the spherical radius be cut smoothly. These problems were solved by running the work on a turret lathe, but at the expense of slowing down production to a crawl.

Progressive manufacturing stages shown of missile hardware made of AISI 4130 steel.

Progressive manufacturing stages shown of missile hardware made of Type 416 stainless steel.



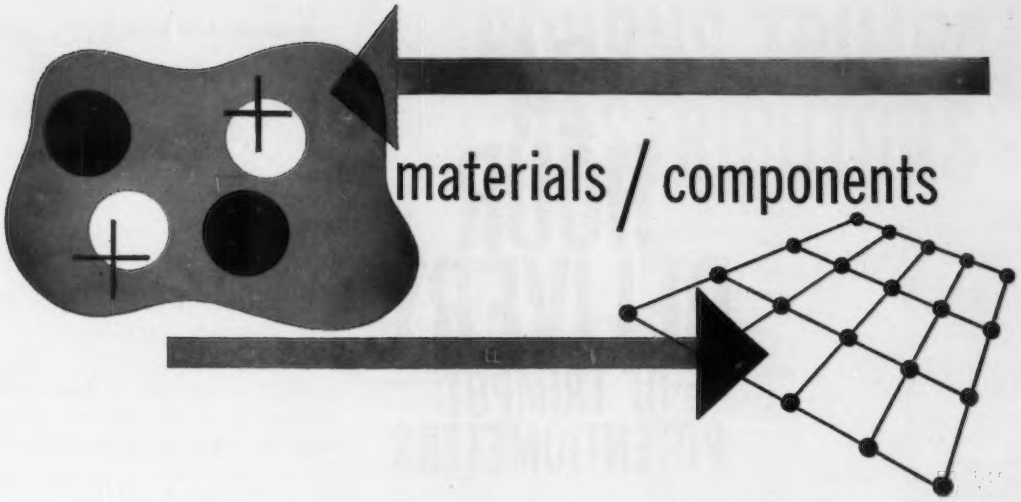
Since finished parts required cadmium plating, threads had to be machined to pre-plate tolerances; a die head was used for threading. This presented another problem—the alloy had tearing characteristics which left a finished thread much rougher than desired. After threading, parts had to be straddle milled. While this operation offered no problem in itself, it was impossible to hold the required finish of 63 RMS on the two flats. These surfaces had to be ground in a separate operation. Final drilling and reaming also presented difficulties; it became impossible to maintain the required surface finish. As a result, the manufacturer experienced a 25 per cent rejection rate after cadmium plating. Much of this trouble came from the roughness of thread and plating buildup on feather edges. The problem was solved somewhat by vapor blasting and buffing of threads before plating, but this added operation forced costs still higher.

With Douglas' approval, Perfecting Service switched from chrome-moly steel to a hardenable grade of stainless—AISI Type 416. The steel was furnished, by Carpenter Steel Co., in the heat treated condition with a tensile strength of 125,000 to 145,000 psi. It was no longer necessary to cadmium plate finished parts; they were passivated instead at comparatively small cost. Improved machinability also increased production by 80 per cent while eliminating fabrication headaches. The same turret lathe operator who previously produced a maximum of 75 pieces a day now turns out 130 to 135 pieces.

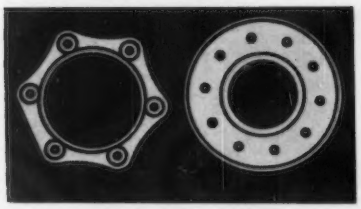
Although the initial cost of the stainless was higher, the actual cost of the part, figuring the savings in plating costs, is the same as it was using the AISI 4130 alloy.

Type 416 stainless is a high-chromium, corrosion-resisting steel machinable at speeds comparable to those used with SAE 1030, 1120, and X1340; its low frictional properties have made it particularly suitable for this application by allowing grinding and polishing of parts easily.

✦




## RUBBER GASKETS RESIST FLUID ATTACK



Special rubber formulation bonds to the metal gasket and provides an absolute seal in fuel line connections. Developed for Convair 880, other seals in family are available in a variety of fluid-resistant materials.

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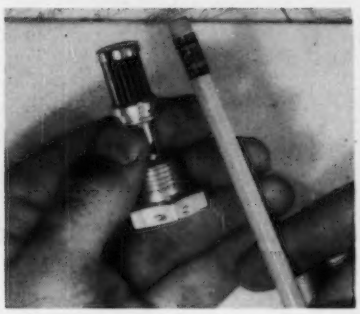
Element will remove 98 per cent of all particles larger than 10 microns, and 100 per cent of all particles measuring 25 microns or greater.



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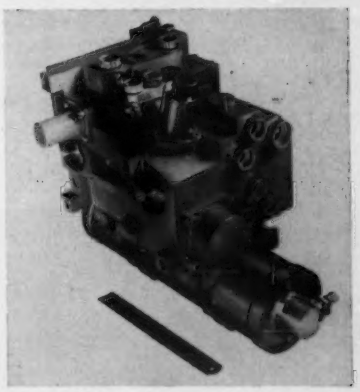
## HYDRAULIC PACK CONTROLS ROCKET ENGINE



New hydraulic unit integrates a complete rocket engine control system into one small package. Operating pressure is 3000 psi. Unit accepts electrical and pressure signals, then controls flow to six exterior ports and two manifolded servo valves by means of five special slide valve assemblies.

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*continued on page 45*

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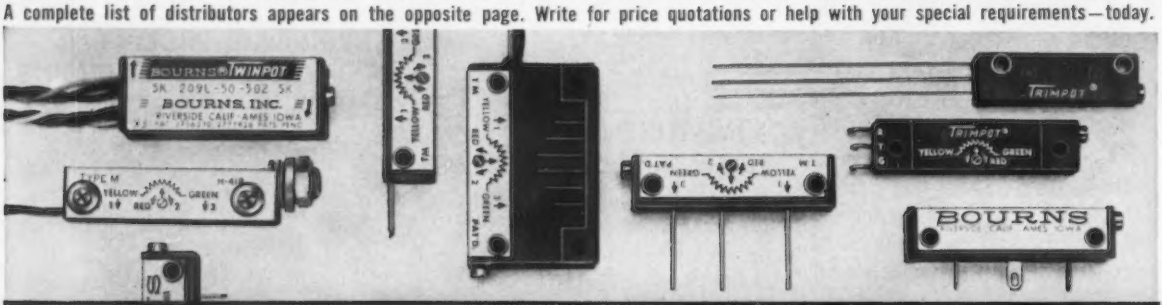


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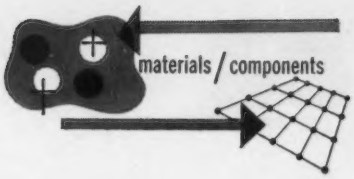
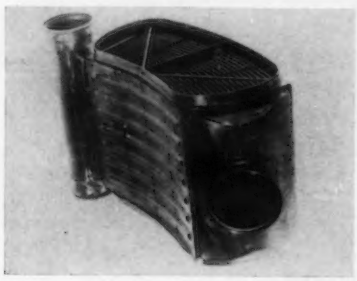



## STAINLESS 316L USED IN HEAT EXCHANGERS

Type 316L stainless steel tubing, a low carbon alloy, has minimized carbide precipitation and is not subject to embrittlement. It is being used by Garrett Corp. in heat exchangers. The 0.005 in. tubing is dimpled to afford maximum surface for heat exchange, and is bent to



fit the configuration of the heat exchanger shell.

*Superior Tube Co.*

**Circle 74 on postcard for more data**

## AL ALLOY 5083 FOR CRYOGENICS

Aluminum alloy 5083 is said to offer a desirable combination of properties for cryogenic equipment. It is one of the strongest of the aluminum-magnesium-manganese alloys, the 5000 series, yet retains excellent weldability and weld ductibility. In addition, it has good resistance to corrosion. Alloy 5083 is available in a wide range of sheet and plate gages and tempers, and in extrusions.

Field experience in cryogenic applications is limited. This accounts for some reluctance to use this new alloy.

*Kaiser Aluminum & Chemical Corp.*

**Circle 75 on postcard for more data**

*continued on next page*

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Phone: BAldwin 4-1111

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Phone: WE 9-7585

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Albert Steinberg & Company
2520 North Broad Street
Phone: BAldwin 3-9400

Almo Radio Co.
913 Arch Street
Phone: WAlnut 2-5918

PITTSBURGH
Cameradio Co.
1121 Penn St.
Phone: EXpress 1-4000
TWX: PG 438
(Note: See Camden, N. J. also)

**RHODE ISLAND**

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Phone: UNion 1-2800

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Phone: ALpine 5-8444

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C & G Radio Supply Co.
2502 Jefferson Street
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BECKMAN Expanded Scale Voltmeters—with accuracy to a fraction... readability to hundredths! That's vital volt-splitting at the moment of "Go—No Go," when operation depends upon precise power input with no room for guesswork. (And no trifling with "average" readings: BECKMAN AC meters give honest, direct rms readings on all wave forms.)

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Helipot offers you hundreds of models ...either AC or DC... in divers shapes, sizes and voltage ranges. (Not to mention voltage monitoring packages, which may include our expanded scale frequency meters and linear scale ammeters, too.) All have uncommon accuracy in common, plus resolution ten times that of conventional meters!

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potentiometers • dials • delay lines • expanded scale meters • servomotors • breadboard parts

## METAL-TO-METAL SEALS

Tiny metal-to-metal seals are designed to meet problems arising out of the increasing development of miniature hydraulic pumps and valves. The seals, called K-Mini, are for applications requiring outside diameters smaller than ¾ in. Standard sizes range down to ¼ in.

*Harrison Mfg. Co.*

**Circle 76 on postcard for more data**

## VITON SEALS

Gaskets of "Viton" synthetic rubber are now being used to seal manifolds in turbo compound engines built by Curtiss-Wright Corp. for DC-7's.

The seals remain efficient at temperatures over 300°F. They are used in lines carrying air between supercharger and cylinder.

*E. I. du Pont de Nemours & Co.*

**Circle 77 on postcard for more data**

## NEW ALUMINUM COATING

Latest addition to line of amorphous chromate coatings for aluminum, "Alodine 1200S," reportedly provides up to 50 per cent faster processing. It is being recommended for use in high production baths such as strip lines.

*Amchem Products*

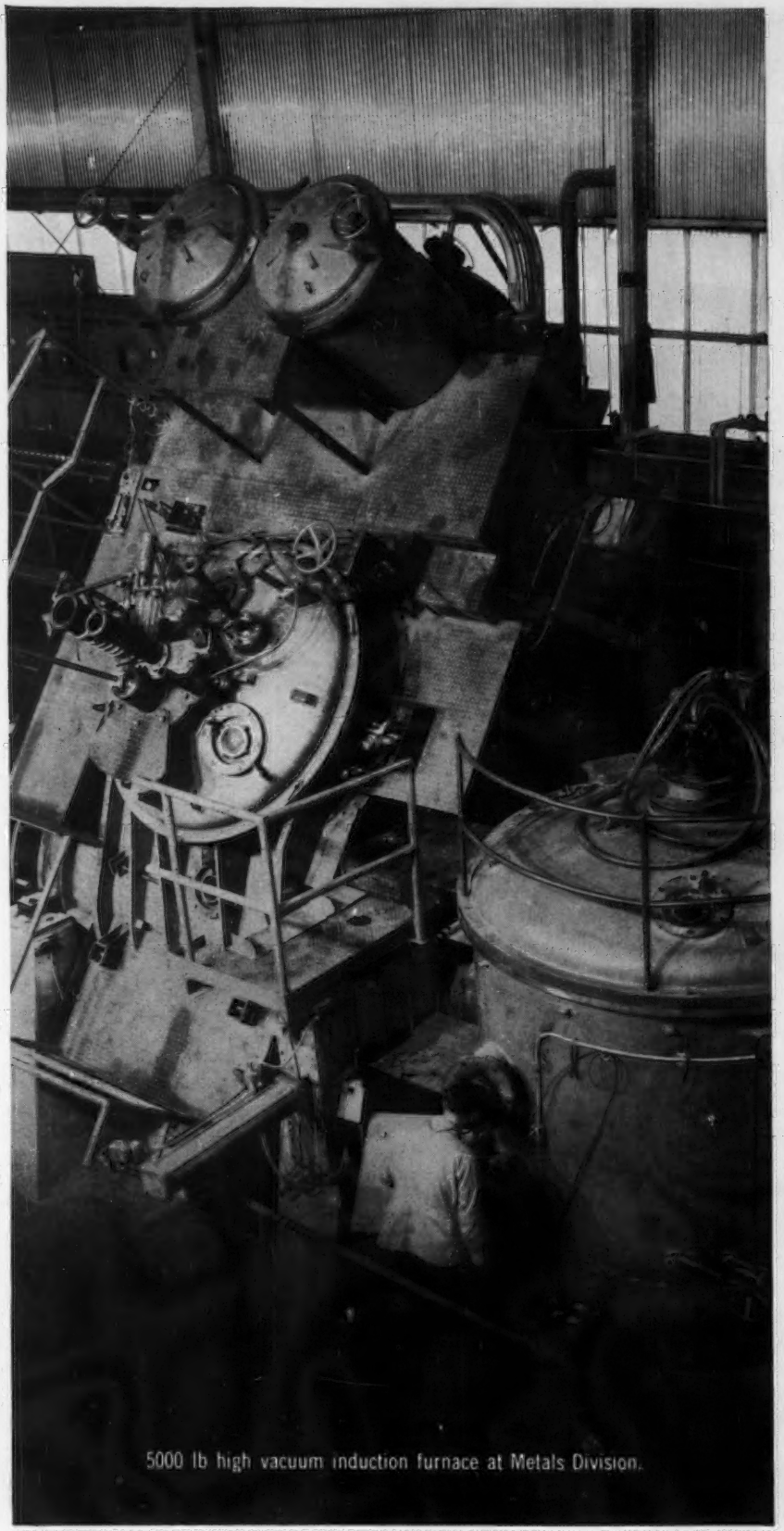
**Circle 78 on postcard for more data**

## CERAMIC SHELL PROCESS SPEEDS CASTING

Ceramic shell method of casting metal permits configurations too large and complicated for lost wax molds. A mass of ceramic matter had to be applied to a wax pattern in the past. New method permits use of relatively thin ceramic shell.

*Mercast Corp.*

**Circle 79 on postcard for more data**



5000 lb high vacuum induction furnace at Metals Division.

## Are you after highest alloy properties in heat-after-heat?

**100 per cent composition control assured by vacuum induction melting**

Highly reactive elements enhance high-temperature alloy properties. Today, only one production metal refining process can effectively control the action of these elements, and—heat-after-heat—meet the most exacting alloy specifications.

The process is vacuum induction melting, and the only specialist in this process is the Metals Division, Kelsey-Hayes Company.

In a specially designed plant which contains seven vacuum induction furnaces with a monthly capacity of 1 million lb, the Metals Division produces over 50 alloys for critical high-temperature, high-stress applications such as aircraft gas turbine buckets and wheels, missile and nuclear components. Alloys like Udimet 500 and 700 were developed by Metals Division. The Division is the leading producer of vacuum induction melted Waspaloy, M-252, and other alloys. Kelsey-Hayes Company, Detroit 32, Mich.

**KELSEY HAYES COMPANY**

Automotive, Aviation and Agricultural Parts
Hand Tools for Industry and Home

*18 PLANTS: Detroit and Jackson, Michigan; Los Angeles; Philadelphia and McKeesport, Pennsylvania; Springfield, Ohio; New Hartford and Utica, New York; Davenport, Iowa; Windsor, Ontario, Canada.*

**K H**

# electronic products

## STRAIN GAUGE RECORDER TRANSLATES DATA

Strain gauge recording system provides a simple and reliable method for digital recording data from mass production testing.

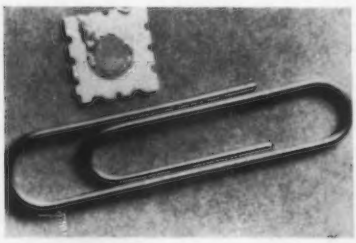
Gives stress data in immediately useable psi figures. Rate of data recording is adjustable from 0.7 to 5 sec/point. System provides for selection of up to 40 strain gauges and is expansible in modules of 10 points up to a capacity of 100 points or more.

*Datex Corporation*

**Circle 60 on postcard for more data**

## GERMANIUM DIODES FOR MICRO-MODULES

Micro - miniature gold-bonded germanium diode, developed in Signal Corps' micro-module program, is shown in



comparison with paper clip. Diode is contained in paper-thin ceramic wafer only 0.31-in. square and 0.016-in. thick.

Diodes are being produced in 12 different terminations as required by specific application.

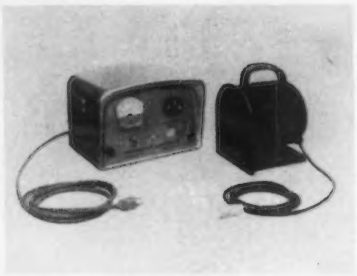
*General Instrument Corp.*

**Circle 61 on postcard for more data**

## INFRARED SOURCE

Controlled infrared source affords accurate general purpose reference.

The radiating element is a pure silver core with a conically shaped cavity. The high thermal conductivity of silver assures uniform temperature along the walls of the cavity. The cavity is coated with a black refractory material to obtain emissivity approaching unity. Emissivity will not change as a function of time. Temperature



range is from 50 to 600°C.

*Perkin-Elmer Corp.*

**Circle 62 on postcard for more data**

## DOPPLER RADAR UNIT DESIGNED FOR AIRLINERS

Doppler radar navigation system weighs 56.5 lb and exceeds ARINC sensitivity characteristics. The system is now undergoing operational evaluation tests by the airlines. Dual installation weighs 98.5 lb.

Eleven tubes and 40 transistors are utilized. Power demand is 200 watts. System includes a transmitter/receiver, computer/tracker, antenna, panel mounted instrument and remote control head.

Self-contained transmitting and receiving system directs three beams of X-band energy toward the earth and measures frequency change.

*Collins Radio Co.*

**Circle 63 on postcard for more data**

## POTENTIOMETER HAS 128 OZ.-IN. STOPS

Production has begun on a new series of ⅞ in.-diam, ten-turn, precision potentiometers.

Two standard temperature ranges are available immediately: (1) power rating of 2 watts at 25°C, derating to zero at 85°C; (2) power rating of 2 watts at 65°C, derating to zero at 125°C. Both have a minimum operating temperature of −55°C.

*Helipot Div.*
*Beckman Inst. Inc.*

**Circle 64 on postcard for more data**

## ELECTRICAL PLUMB-BOB

New instrument used to check "erectness" of missiles on launch pad is a sensitive electrical plumb-bob. The unit can determine true vertical within three minutes af arc.

The Vertical Sensor consists of an iron pendulum suspended in a small tube, 5-in. long, filled with a damping fluid. Miniature coils spaced 90 deg apart at the bottom of the tube form magnetic pickups which detect any deviation of the pendulum from center position.

The unit weights 2½ oz.

*Eclipse-Pioneer Div.*
*Bendix Aviation Corp.*

**Circle 65 on postcard for more data**

## MICROELEMENT WAFERS

A complete line of custom and standard micro-element wafers are offered for experimental and production requirements in micro-miniature circuitry.

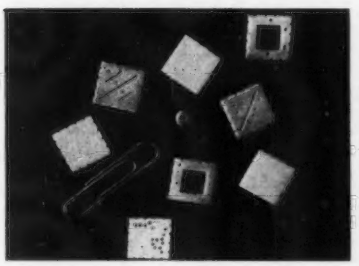
The wafers, fabricated from high alumina ceramic, steatite, glass or quartz, can be supplied in thicknesses down to 10 mils, less on special order. Units are drilled, ground and finished for end or substrate applications, with hole sizes from 10 mils. Tolerances on hole diameters, slots, channels and edge notches are held to within 0.0002 in.

Close tolerances have been made possible through use of precision optical techniques combined with a highly developed ultrasonic machining process.

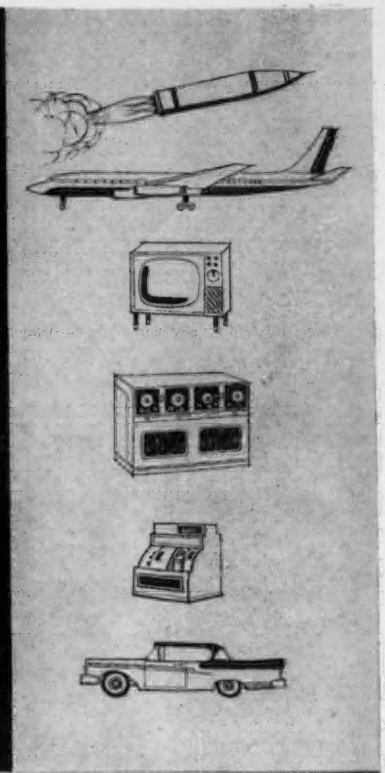
*Zenith Optical Lab.*

**Circle 66 on postcard for more data**

*continued on page 51*




one product ties all these together...



**BERYLLIUM COPPER** ELECTRICAL CONNECTORS

Where performance is mandatory . . . where failure must not occur . . . "Berylco" beryllium copper provides the vital link between electrical components in aircraft/communication/business machines. Excellent fatigue life, combined with the high spring and electrical properties of beryllium copper, insure positive (corrosion-free) contact with the *minimum of surface contact resistance.*

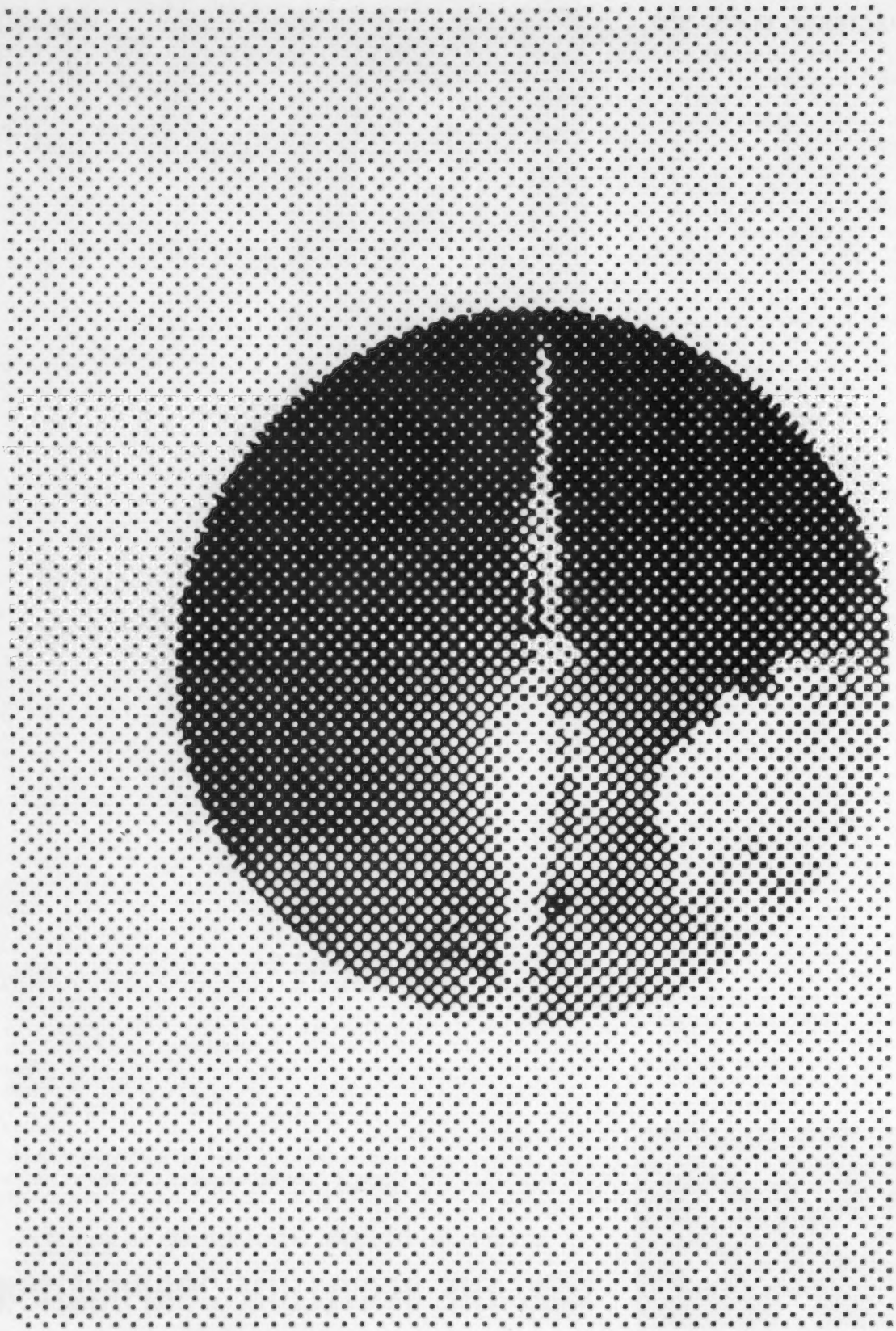
Do you have such a problem? Write us today for descriptive literature and engineering data. Qualified technical assistance is always as close as your phone.

**VISIT US AT THE METAL SHOW, CHICAGO, NOVEMBER 2-6, BOOTH 1636**

BERYLCO®

**THE BERYLLIUM CORPORATION**

P. O. Box 1462, Reading, Pennsylvania



*There are 7,500 dots shown here.*
*This is the number of engineers in the eight divisions of Martin. And 40 percent of these—the 3,000 dots in the circle—are electronics/electrical engineers.*
*It is this specialized capability that enables Martin to develop electronic systems which anticipate the exacting demands of the missile-space age.*
*Example: A Martin electronic system known as Master Operations Control (MOC) has been a vital factor in the exceptional performance of TITAN. By automatically checking the hundreds of systems necessary to successful flight, MOC has removed much of the human error from complicated countdown procedures.*

MARTIN

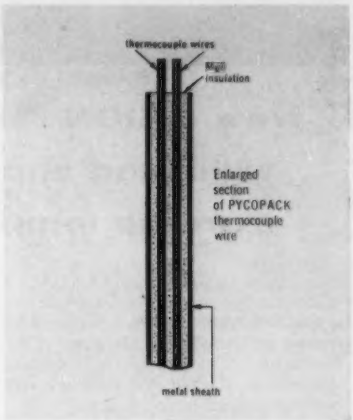
*The eight divisions of The Martin Company are Activation, Baltimore, Cocoa, Denver, Nuclear, Orlando, RIAS, and Space Flight.*

Circle 18 on Inquiry Card

electronic products

## THERMOCOUPLE IS PACKED IN MgO

Pycopack thermocouple wire, a magnesium-oxide packed, metal-sheathed unit, is now available in seven sizes ranging from 5/16 to 1/40 in. OD. Originally designed for high temperature, limited-space applications in the atomic energy field,



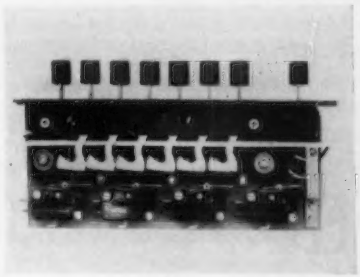

thermocouple has usage in all industries where high temperatures, size and adaptability are primary factors.

*Pyrometer Co. of America Inc.*
**Circle 67 on postcard for more data**

## CODE BAR SWITCH

Code Bar Switch features input by octal or decimal push buttons, output by binary-coded contact closures. It meets a recurring need for a keyboard switch featuring direct binary-coded outputs. Conversion from

*continued on next page*



(Advertisement)

## New UNION readout instruments withstand shock, vibration and extreme temperature changes

Union Switch & Signal's new READALL* readout instrument replaces complicated systems of lights and relays for reading, storing or transferring all types of information for industrial and military applications. It is not to be confused with conventional indicating devices.

**Designed to meet requirements of MIL-E-5422D.** The new READALL readout instrument is precision-built and provides instantaneous and continuous operation under conditions of shock, vibration and extreme ranges in temperature. The digital display includes characters in numerical sequence from 0 to 9 plus two blank spaces. 7/32-inch characters can be illuminated red or white as desired; when not illuminated, they appear white against a black background.

**Reliability.** Performance through one million random operations is an inherent feature of the new READALL instrument. Each module is gasket-sealed in its case to exclude moisture and seal out foreign particles. An especially thin enclosed DC motor, containing ball bearings, permits more efficient operation.

**Modular Construction.** A unique feature of the readout instrument is its modular construction. It can be used individually or in groups to display multiple characters in a single case.

**Direct Code Translation.** The operation of the READALL readout instrument is based on a positioning system using a four-bit code. The visual display is the result of a direct electro-mechanical conversion of a binary signal to a decimal read-out. There is no need for additional conversion equipment. Separate code and motor circuits permit the use of the readout instrument in low-level circuitry.

**Electrical and Visual Data Storage.** Once positioned, the information is displayed until a new code is transmitted to the instrument. No power is consumed while the information is retained. This data may be stored or read-out electrically for further transmission or recording.

**Operate Time.** The operate time varies from 0.1 second to 1.0 second depending on character position.

**Weight and Size.** Maximum weight including case is seven ounces; without case, four and one-half ounces. Size encased is 5 13/64 inches long, 1 47/64 inches high and 39/64 inch wide. The new READALL instrument is designed for operation over a temperature range of −54°C to +71°C in humidities up to 100% and altitudes up to 70,000 feet. For more information, write for Bulletin 1019.

*Trademark

*"Pioneers in Push-Button Science"*

UNION SWITCH & SIGNAL
DIVISION OF WESTINGHOUSE AIR BRAKE COMPANY
PITTSBURGH 18, PENNSYLVANIA

electronic products

octal or decimal digit to the corresponding binary code per digit can now be achieved without resorting to multiple-relay contact arrangements.

Conversion to binary code is performed by cam-type code bars. Binary coded outputs are in the form of Micro Switch contact closures with double throw contact arrangements. A mechanical interlock permits only one push-button key to be depressed at a time by automatically releasing any previously depressed button.

*Computer Control Co.*

**Circle 68 on postcard for more data**

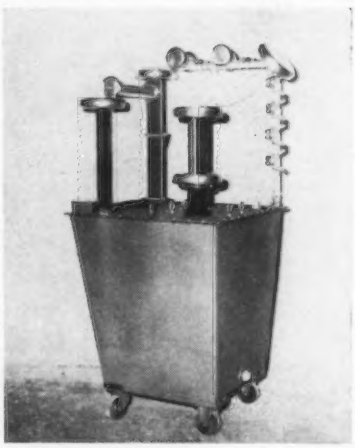
## OVERPOTENTIAL TESTER

A new 150 KV DC Overpotential Tester is now available. Rated at 5 ma., 20 ma. is available for burning. A small gas-filled tank with extended header houses the plate transformer. The header houses the air insulated components.

To avoid use of a large and heavy oil-filled tank which would be required to house all high voltage components, rectifiers and filter, this air insulated design features great savings in size and weight.

*Peschel Electronics Inc.*

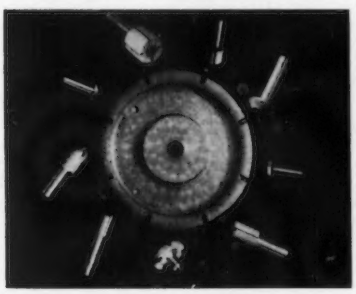
**Circle 69 on postcard for more data**



## ADJUSTABLE BUSHINGS PROVIDE EXACT FITS

Mechanical adjustment of this adjustable well thickness bushing permits easy variation of radial dimensions.

Series of alternate male and female segments are aligned axially. Axial compressive force



on ends of the bushing causes smaller diam. of male segments, reduced I.D. of bushing female segments assume larger diam., thus increasing O.D. of bushing.

*Globe Bushing Corp.*

**Circle 80 on postcard for more data**

## STENCIL DEVELOPED FOR MARKING METALS

Pocket-size battery-operated cartridge marker marks metals permanently by electrolytic stencil etching.

Developed for missile inspection, unit has three interchangeable stencil sizes for marks up to max rectangular area of ½ in. by 1½ in. Marker is 1½ in. diam., 8 in. long, weighs 10½ oz.

*Lectroetch Co.*

**Circle 81 on postcard for more data**

## MICROFILM FILING PLAN

Microfilm file groups in sequence the catalog pages of all firms supplying a particular item. Index system allows any product to be located in seconds.

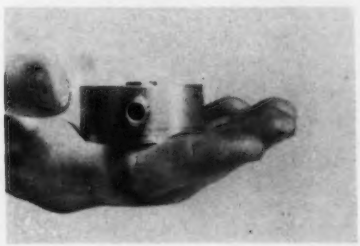
A set of microfilm magazine reels contains over 100,000

catalog pages, specification and data sheets. A variable speed switch starts sequence for loading film into microfilm reader-printer. Pages are viewed full size on a 13 in. x 13 in. screen.

Catalog for use with the reader will cover components, materials and engineering department equipment in aircraft or missile plants.

*Technical Services,*
*Div. of Rogers Publishing Co.*

**Circle 82 on postcard for more data**



## SPACE-SAVING AIR CYLINDERS

This "pancake" line of low pressure air cylinders permits air power to be used where it was previously impossible because of space limitations. Developed primarily for the tooling industry, cylinders have pressure ratios from 1:1 (line pressure) to thrice line pressure. Strokes range from .010 to 1 inch.

*Fabco*

**Circle 83 on postcard for more data**

*continued on page* 55

# Solid Fuels are simple—

Circle 20 on Inquiry Card

# but!

Whether the rocket power be for the Army's Sergeant, the Air Force's Minuteman or tomorrow's 50,000,000 lb. thrust motor it begins with globs and strands of fuel held in the asbestos-gloved hands of the research chemists.

For more than ten years the research scientists in THIOKOL's Rocket and Chemical Divisions have been continuously engaged in rapidly expanding programs of propellant development.

In these endeavors one fact is common: new propellants are cast into rocket motors only after many thousands of hours have gone into research and testing. For every successful propellant formula there are many, many frustrating failures. This is the way of research. Success, even though it comes slowly, is the reward.

Fortunately, success has come to THIOKOL research scientists in abundance and with regularity.

The variety of career opportunities at THIOKOL is large and expanding, including:

**Propellant analysis and formulation • Polymer research • Fluorine and metal hydrides synthesis • Shock wave phenomena • Combustion processes • High vacuum techniques • Fast reaction kinetics • Servo system and electro mechanical design • Instrumentation • Ion and plasma propulsion • Magnetohydrodynamics • Thermodynamics • Solid state physics.**

There may be a place for you on the team, working on THIOKOL — developed-and-built rocket powerplants used in the Falcon, Sergeant, Matador, Nike Hercules, Lacrosse, X-17, Minuteman, Pershing, Nike Zeus, Sparrow III, X-15, Bomarc, Little Joe, and Bullpup.

For further information contact Personnel Director of any of these plants: Huntsville, Ala.; Elkton, Md.; Moss Point, Miss.; Brigham City, Utah; Trenton, N. J.; Bristol, Pa.; Denville, N. J.; Marshall, Texas.

Thiokol®

is Research to the Core

THIOKOL CHEMICAL CORPORATION

Bristol, Pennsylvania

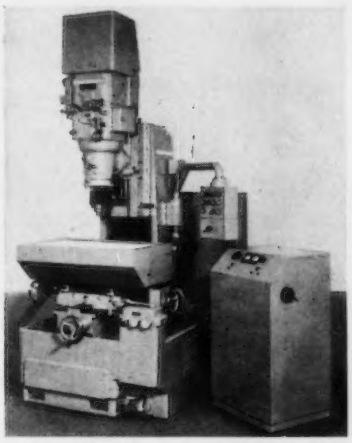
®Registered trademark for the Thiokol Chemical Corp. for its rocket propellants, liquid polymers, plasticizers and other chemical products.

Circle 20 on Inquiry Card

## NEW ELECTROJET LINE INTRODUCED

A complete new line of 33 building block machine tools for electrical discharge (electrospark) machining is being introduced.

The tools are "built up" mostly from 16 basic units: two bases, two slides, four workheads, four base-tank units, and four power supplies. Many of these building blocks are completely interchangeable.



*Cincinnati Milling Machine Co.*

**Circle 84 on postcard for more data**

## MECHANICAL ARM

New concept in automatic machinery, called "TransfeRobot," will soon by available. Performs diverse tasks in parts-handling, assembling and machine operation. Electronic brain controls mechanical arm. Set-up will work in conjunction with much existing machinery.

*USI Robodyne Div.*
*U.S.I. Industries*

**Circle 85 on postcard for more data**

*continued on next page*


Straightaway®

**SOUND PROTECTOR**

**– a pound of prevention worth $2,000* an ounce**

Whether from a shrieking jet engine or an earsplitting riveter, noise CAN cost you untold thousands of dollars a year in employee compensation claims and loss of production.

Unknown to the employee, excessive noise gradually robs him of his hearing and his working efficiency. Today, compensation for loss of hearing can go as high as $33,000* — Arizona's maximum allowance.

Straightaway, muff-type, Sound Protectors guard your employees from abnormally loud noise. They are available in either a standard or a communication model, which attenuates an extra 10 decibels of sound, and includes a push-to-talk button (or toggle switch) in the mike shield.

**SOLD DIRECT! YOU SAVE MONEY!**

**Model 372-8A (standard) $12.00 each (1-99). $11.00 each (100 or more.) Communications Model 372-8BM $83.25 each. Quantity prices on request.**

DAVID CLARK COMPANY, INC.

Pioneer designer and manufacturer of space suits

366 PARK AVENUE
WORCESTER 2, MASS.

DAVID CLARK COMPANY
366 PARK AVE., WORCESTER 2, MASS.

Gentlemen: Please ship one Straightaway Model #372-8A, for trial testing. If O.K. will include on my first order.

NAME.....

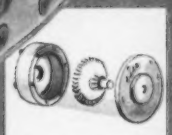
COMPANY.....

ADDRESS.....

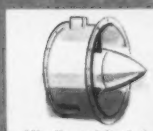
CITY.....STATE.....

Circle 21 on Inquiry Card

De-icing entrance guide assembly for T-56 turbo prop engine.



Gas Turbine engine hydraulic, pneumatic and fuel components



Missile and Rocket Engine components, turbine blades, nozzle & stator vanes.

Turbines, blowers, power components & valves.

# TOUGH ALLOY SPECIALISTS

*for extreme temperatures and high pressures*

Extreme stresses and high temperatures in jet, missile and rocket engines require components and assemblies manufactured from superior metals that are difficult to machine and form. Specialized techniques for manufacturing with tough alloy exotic metals are exclusive processes of Turbo Products. Turbo is one of America's major sources for high alloy gas turbine and missile and rocket power plant components—from experimental to production. On a typical contract, 28,000 turbo jet components were produced per month from N-155, each unit requiring 83 separate manufacturing operations. We invite your inquiry.

POLY INDUSTRIES

*formerly Turbo Products*

*Write for new Turbo facilities brochure.*

**TURBO PRODUCTS DIVISION**

12177 Montague Street • Pacoima, California

## ARBORS AND CUTTERS SPEED METAL REMOVAL

Splined milling arbors and cutters reportedly speed metal removal rates by 92 per cent to 400 per cent with corresponding increase in cutter life.

Both the arbors and the spacers used with them are splined to increase resistance to torsional deflection of the assembly. Milling cutters are also splined.

Improvement in heavy duty milling performance is particularly noted in machining of high-strength alloys in the hardened state.

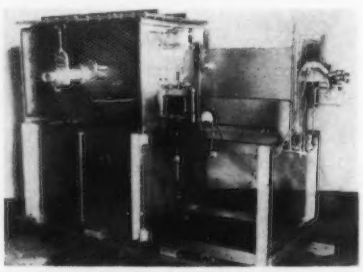
*Pratt & Whitney Co.*

**Circle 86 on postcard for more data**

## 3400° F FURNACE

Molybdenum heated furnace permits temperatures of 3400°F in a hydrogen atmosphere.

Saturable reactor and radiation pyrometer control heating. Refractory-lined water-cooled zones control cooling. Automatic flame curtains protect



furnace atmosphere when the door is opened.

*W. P. Keith Co.*

**Circle 87 on postcard for more data**

## TC-2 CALIBRATES THERMOCOUPLES

Model TC-2 calibrates thermocouples used for controlling and recording test temperatures during materials testing.

Calibrator replaces usual stainless steel ice bath with a constant temperature thermocouple reference junction.

*Arcweld Manufacturing Co.*

**Circle 88 on postcard for more data**

## AC-DC WELDER AND AC POWER UNIT

Combination arc welder and power unit is designed as a power source for tungsten-inert-gas-shielded arc welding.

Driven by a gasoline engine, unit provides current for either AC welding or DC welding. It provides single phase, 110/220-volt AC power of 10 KW capacity (up to 3 KW available while welding).

*Hobart Brothers Co.*

**Circle 89 on postcard for more data**

## HIGH VACUUM TESTING

Model 59-TA tubular furnace is designed for tensile and creep testing of metals and alloys within a high vacuum up to 4,000°F. Unit measures about 44 in. high, 11 in O.D. It consists of tantalum heating element surrounded by tantalum and molybdenum radiation shields, plus other assemblies.

*Marshall Products Co.*

**Circle 90 on postcard for more data**

## MISSILE COMPONENT WEIGHT, C.G. LOCATOR

Weight and center-of-gravity locator evaluates ballistic missile components, parts of re-entry vehicles.

Locator is based on null-balanced mass and lever principles. Since it measures essentially mass and mass moments rather than weight, it will repeat measurements at all latitudes and altitudes.

*Dynametrics Corp.*

**Circle 91 on postcard for more data**

*continued on next page*

PROTECTING THE PROTECTOR!
the unprecedented launching complex for the TITAN intercontinental ballistic missile is fully protected, above ground and underground, with Zincilate
Artist's conception of Titan Launching Complex; Courtesy American Machine & Foundry Company.

Surfaces of structural steel and aluminum on the Air Force's Titan Missile Launcher System are protected against corrosion with Zincilate. Zincilate is supplied to American Machine & Foundry Company, associate contractor under the Ballistic Missiles Division of the USAF.

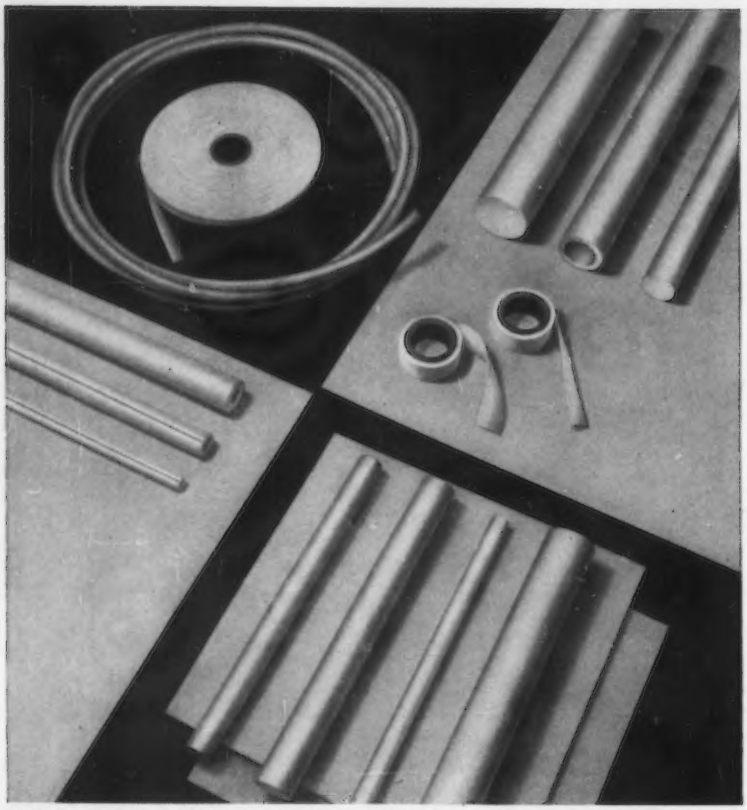
Zincilate, as modern as the missile equipment it protects, provides true galvanic protection to iron, steel and aluminum. Easily applied, before, during or after fabrication, without requiring special equipment or even mixing. Now in its 13th consecutive year of sea coast exposure tests, Zincilate has yet to show any signs of rust. Write for complete information; samples available.

PROTECTION that SELLS your PRODUCTS

INDUSTRIAL METAL PROTECTIVES

420 Homestead ave. • Dayton 8, Ohio • BAldwin 2-6747, 2-6748

# LOOK TO R/M TO MEET ALL YOUR TEFLON* NEEDS



**R/M—headquarters for "Teflon" products.** R/M can meet all your needs for sheets, rods, tubes, tape, thin-wall tubing (available with permanent color striping for identification purposes) and bondable "Teflon." R/M can also supply molded, machined and extruded "Teflon" made to your exact specifications.

"Teflon's" many remarkable properties have established it as an important material for use in aircraft, missiles and spacecraft. Yet when you select "Teflon" for a particular job, you solve only part of your problem. Equally important is the selection of a source of supply you can depend on for both competent engineering assistance and the production capability needed to meet your exact specifications and quantity requirements. This *complete* "Teflon" service is yours from R/M.

A pioneer in "Teflon" application and fabrication research, R/M offers design guidance that can help assure maximum part performance, and its ample production facilities can supply "Teflon" in the form best suited to your needs. Learn more about R/M's complete "Teflon" service—and how it can benefit you—by contacting your nearest R/M district office. Or write Plastic Products Division, Manheim, Pa.

*A Du Pont trademark

R/M

**RAYBESTOS-MANHATTAN, INC.**

**PLASTIC PRODUCTS DIVISION FACTORIES: MANHEIM, PA.; PARAMOUNT, CALIF.**

Contact your nearest R/M district office listed below for more information or write to Plastic Products Division, Raybestos-Manhattan, Inc., Manheim, Pa.

BIRMINGHAM 1 • CHICAGO 31 • CLEVELAND 16 • DALLAS 26 • DENVER 16 • DETROIT 2 • HOUSTON 1
LOS ANGELES 58 • MINNEAPOLIS 16 • NEW ORLEANS 17 • PASSAIC • PHILADELPHIA 3
PITTSBURGH 22 • SAN FRANCISCO 5 • SEATTLE 4 • PETERBOROUGH, ONTARIO, CANADA

RAYBESTOS-MANHATTAN, INC., Engineered Plastics • Asbestos Textiles • Mechanical Packings • Industrial Rubber Sintered Metal Products • Rubber Covered Equipment • Abrasive and Diamond Wheels • Brake Linings Brake Blocks • Clutch Facings • Laundry Pads and Covers • Industrial Adhesives • Bowling Balls

## MATERIALS INDICATE HIGH TEMPERATURES

Temperature indicating materials for 2100° and 2200°F have been added to pellit line.

Expanded line includes both Tempilaq° and Tempilstiks° with higher ratings under development to meet expanding temperature boundaries.

Tempil° Corp.

**Circle 92 on postcard for more data**

## TAPE-CONTROLLED TURNING AND DRILLING

Numerically-controlled lathe and drilling machines have specific low-cost objective. Tape-controlled lathe is in the $30,000 bracket, employs point-to-point positioning control, six position tool turret. Drilling machine is in the $10,000 price bracket. It consists of a numerical control console with tape reader, a rugged table unit, pneumatic pack and 24 in. sliding head drill.

*Cincinnati Lathe and Tool Co.*

**Circle 93 on postcard for more data**

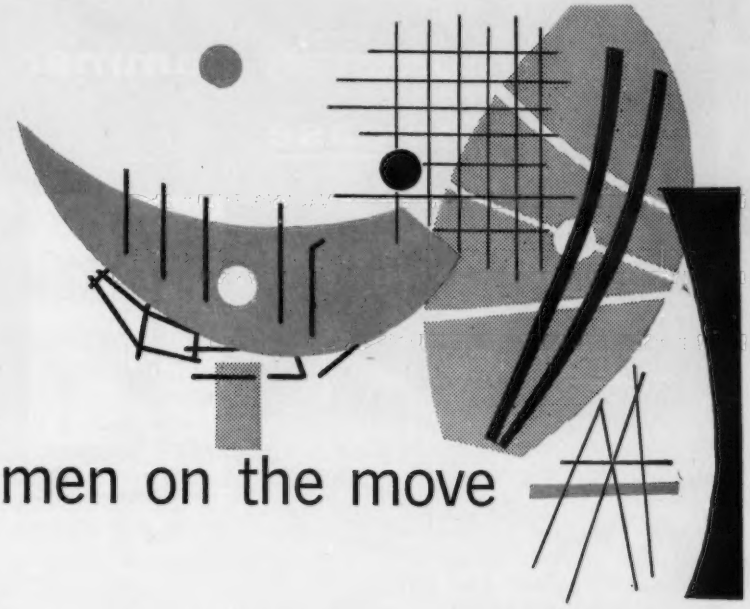
## TWO-AXIS SYSTEM OF NUMERICAL CONTROL

Two-axis numerical control system permits machining of complex part configurations on rotary profile milling machines.

Typical parts machined with mills controlled by the 2-axis system: stainless steel jet engine housings, two dimensional cams, spur gear type configurations, transmission housings. High-speed tape reader is available with system.

*Industrial Controls Section*
*Bendix Aviation Corp.*

**Circle 94 on postcard for more data**



# men on the move

HARVEY C. TAFE, named director of foreign sales-military, Convair Div., General Dynamics Corp.

WILLIAM G. GISEL, appointed acting general manager of the Niagara Frontier Div., Bell Aircraft Corp.

HARRY A. FERULLO, appointed weapons systems manager for the Missiles & Space Systems Div. of United Aircraft Corp.

FRED A. KLEMACH, appointed Missile Systems Manager for Vickers Inc.

DR. BENJAMIN P. BLASINGAME, appointed director of engineering for the AC Spark Plug Div. of General Motors operations in Milwaukee.

Hewson Lawrence
Aerojet-General

John J. Burke
Siegler

HEWSON LAWRENCE, appointed director, division customer relations, Aerojet-General Corp. L. M. LIMBACH, named corporate director of manufacturing.

JOHN J. BURKE, elected vice-president of The Siegler Corp.

MOORMAN R. BALIS, appointed director of contracts and planning, Bendix Products Div.—Missiles. JACK A. REED, appointed contracts manager. T. S. TORIAN, appointed associate director of the contracts and planning departments.

HAROLD D. GERMANN, appointed general sales manager, Leach Corp.

Moorman R. Balis
Bendix Products Div.

Harold D. Germann
Leach Corp.

GORDON A. CROWE, appointed chief process engineer for the Engineering Science Div., American Metal Products Co.

WILLIAM H. KNOWLES, appointed sales manager, Defense Div., Budd Co.

CHARLES D. GOULD, appointed Chief Engineer at the Landsverk Electrometer Co.

DR. WILLIAM L. WHITSON has been named a vice president of Daystrom, Inc.

PHILLIP T. MADDEX, appointed chief engineer for the United States Borax & Chemical Corp.

VICTOR P. KOVACIK, named research requirements manager of the Tapco Group of Thompson Ramo Wooldridge. M. JAMES CORBETT, named development requirements manager.

EVERARD M. LESTER, appointed director of manufacturing of American Machine & Foundry Company's Government Products Group.

GENE A. GOEDJEN appointed manager—military engine sales, production engine department, at General Electric's Flight Propulsion Div.

FREDERICK D. DODGE, appointed chief engineer of Minneapolis-Honeywell's Missile Equipment Div.

ROBERT S. TURNER, named head of flight testing at the Martin Company's Baltimore Div. DR. HUGH L. COX, appointed lead engineer on advanced classified projects at Martin-Denver.

WILLIAM G. CROOK, JR., appointed sales engineer, Foundry Products Div., Cooper Alloy Corp.

WARREN R. SMITH, appointed assistant to the president, Fairchild Engine and Airplane Corp.

Warren Bassett
Electric Steel
Foundry Co.

Philip K. Reily
Atlantic Research

WARREN-BASSETT, named manager of sales for Electric Steel Foundry Company's service to the aircraft-missile industry.

PHILIP K. REILY, JR. has assumed responsibility for the Development Department of Atlantic Research Corp.

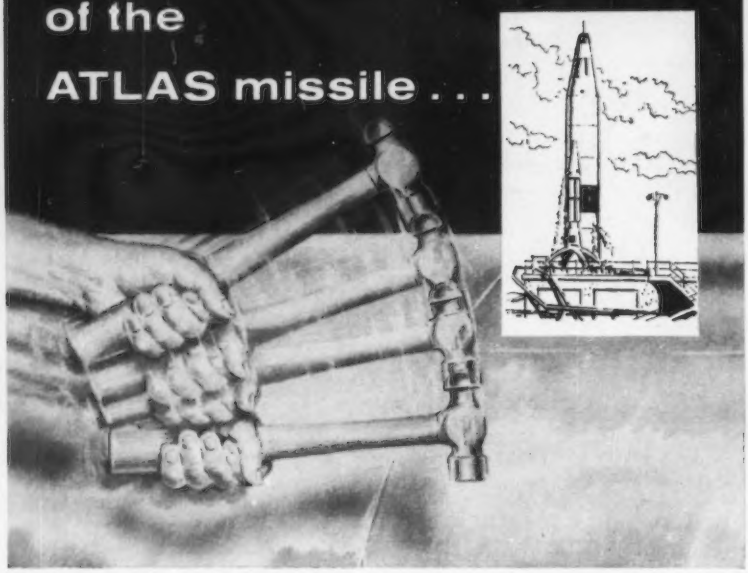
FRANK P. DELUCA, JR., appointed executive vice president of Acoustica Associates, Inc.

JOHN A. STIEHL, appointed manager of administration at Northrop International. division of Northrop Corp.

HARRY D. STONE, named manager, sales and marketing, Metals Div., Kelsey-Hayes Co.

*continued on next page*

# How an ordinary hammer proved the case of the ATLAS missile . . .



The body of the missile, essentially one big fuel tank, is similar in principle to an inflated football. Convair-Astronautics broke new ground in missile design by developing a super-strong structure with a comparatively thin stainless steel skin to keep weight to a minimum. This stainless steel skin is so thin that the interior has to be pressurized to preserve the shape of the body as propellants are consumed in flight, or when the missile is being transported on the ground.

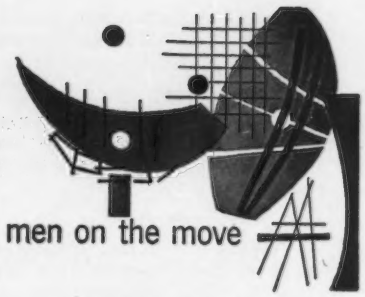
Some critics, however, thought the body was too fragile—"You could dent it with a hammer." So, recently, when the Scientific Advisory Board, engaged in a re-evaluation of all missile programs, arrived at Convair-Astronautics to take a reading on the ATLAS, they found that Convair had thoughtfully placed a number of hammers within easy reach of a finished missile. "Go ahead, bash it," invited Convair. The SAB members swung lustily. *Not a dent was registered*, for, although the walls are thin, the stainless has a minimum tensile strength of 200,000 psi.

This stainless steel skin material, supplied by Washington Steel, required extremely close control of mechanical properties and gauge tolerance which are regularly produced through Washington Steel's long experience with precision rolling equipment.

*Stainless Steel—the Space Age Metal*

**Washington Steel Corporation**

11-H Woodland Avenue
Washington, Pa.


WILLIAM L. VANDAL has joined Aeronutronic, Div. of Ford Motor Co., as manager, Central Environmental Test.

Kenneth Dollinger
Sanders Associates

Daniel W. Ruple
Titeflex

KENNETH DOLLINGER, designated project manager of the Target Seeker development for the Eagle missile at Sanders Associates.

DANIEL W. RUPLE, appointed vice president and general manager, Pacific Div., Titeflex, Inc. GEORGE DERUM, appointed manager of marketing for the Commercial Sales Div.

C. M. MARTENSON, elected President and General Manager of Hydraulic Research & Mfg. Co.

DIXON FISKE, appointed sales product manager for the Eemco Div., Electronic Specialty Co.

FRANK MANOV has joined Electro-Optical Systems as supervisor of a newly formed satellite and space defense studies group. A. T. FORRESTER has joined Electro-Optical as head of the Ion Propulsion Lab in the Fluid Physics Div.

D. A. YOUNG, appointed chief design engineer for the Engineering Science Div., American Metal Products Co.

CAPT. NORMAN LEE BARR, has joined Republic Aviation Corp. as chief of Space Environment and Life Sciences research.

T. F. DIXON, named director of engineering in a major expansion of the technical organization of Rocketdyne, div. of North American Aviation Inc.



Circle 25 on Inquiry Card

Circle 13 on Inquiry Card

Fig. 2

Fig. 2, above. Sonic measurement of finished Hydrospun Nike Hercules nose cones. Thickness of the tapered wall is held to ± .006". Photos and data courtesy of Lycoming Div., Avco Corp., Stratford, Conn.

Cincinnati® Hydroform® machines are built in 8", 12", 19", 23", 26" and 32" sizes; Hydrospin® machines are built in a variety of styles and sizes to meet your production requirements.

## Another missile nose gets off the ground via

# CINCINNATI Hydroform/Hydrospin!

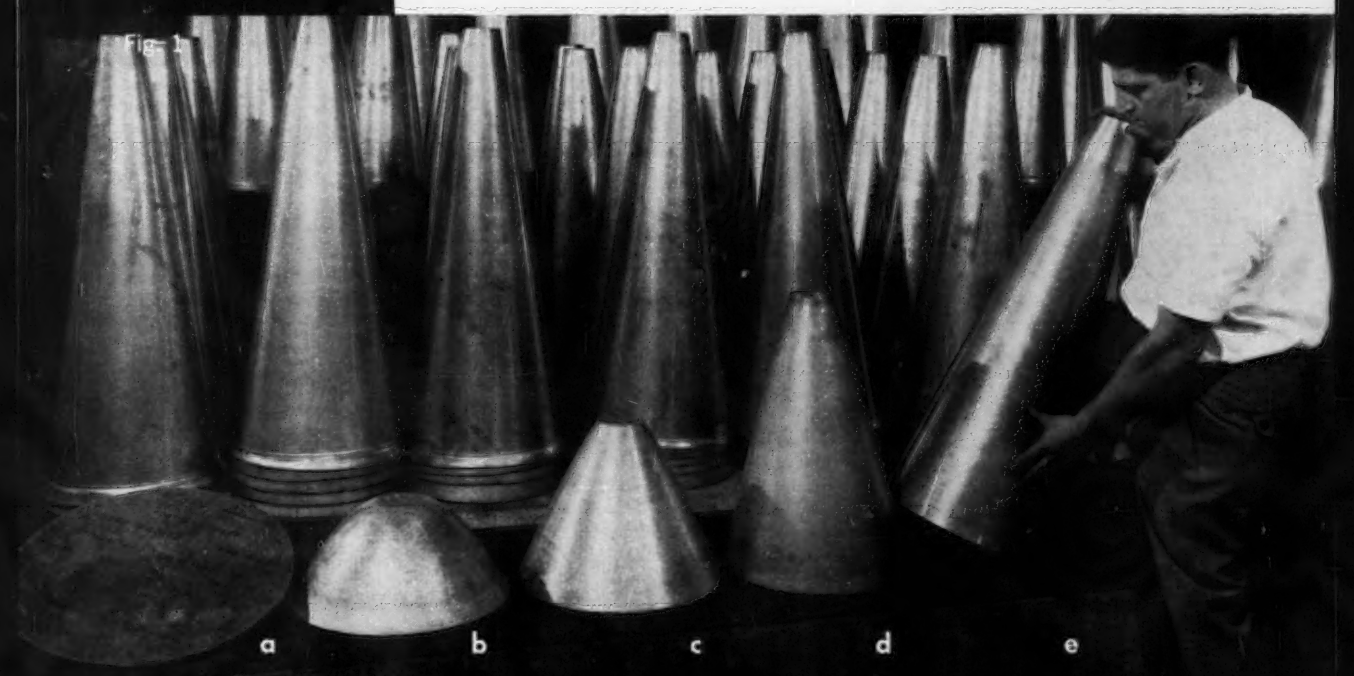
*NIKE HERCULES NOSE CONES* are in quantity production at Lycoming (Stratford) Div., Avco Corporation, subcontractor to Douglas Aircraft Co., Inc., Charlotte Div., for these missile components. The success of this work is due to the unique capabilities of Cincinnati Hydroform and Hydrospin machines to form the nose cone to the desired contours and to the degree of precision required.

In the foreground of Fig. 1, below, are shown the five work stages to produce the finished part. "A" is the 17" dia. blank of ½" thick, annealed 6061 aluminum, which is preformed by a Cincinnati Hydroform to the shape shown at "B". Parts "C", "D" and "E" represent the nose cone shape progression through three passes on a Cincinnati Hydrospin. Wall section of the final shape is tapered from .078" at the nose to .125" at the aft end, with wall thickness controlled by the Hydrospin to ± .006". The metal of the finished part is solution heat treated to a T6 condition.

This winning Hydroform-Hydrospin combination is aiding missile and many other component parts manufacturers to produce formerly difficult or impossible sheet metal shapes to specified tolerances . . . while producing major savings in *time*, *tooling*, *labor* and *material costs* as well. Look into the many advantages of Hydroforming and Hydrospinning. Call in a Meta-Dynamics Division field engineer for full details.

**Hydroform/Hydrospin**
META-DYNAMICS DIVISION
Machines for Metal Forming and Heat Treating
THE CINCINNATI MILLING MACHINE CO.
Cincinnati 9, Ohio, U.S.A.
CINCINNATI

Fig. 1



# AIRCRAFT & MISSILES DIGEST OF RECENTLY PUBLISHED TECHNICAL MATERIAL

producibility REVIEW

## GOVERNMENT RELEASES

PERFORMANCE OF FLARED EXHAUST DUCTS SUITABLE FOR JET FLAP APPLICATIONS. R. C. Lopiccolo, R. Z. Nelsen, Jr., and A. Palm-Leis. A 48-page report discusses controlled area method used to design effective flared exhaust ducts. These ducts would direct jet-engine exhaust to provide lift as well as propulsion to an aircraft — the principle of the jet wing or jet flap system. (Order PB 151466 from OTS, U. S. Department of Commerce, Washington 25, D. C.; price: $1.25)

DETERMINATION OF MATERIALS DESIGN CRITERIA FOR 6A1-4V TITANIUM ALLOY AT ROOM AND ELEVATED TEMPERATURES. J. K. Childs, and M. M. Lemcoe. A 275-page report presents useful design criteria for the 6A1-4V titanium alloy, a high-tensile-strength, thermally-stable, hydrogen-tolerant alloy which has shown promise as a lightweight structural sheet material. Tension, compression bearing, and shear properties were determined from 75 to 1000°F. (Order PB 151274 from OTS, U. S. Department of Commerce, Washington 25, D. C.; price: $4.)

THE AIR FORCE INTEGRATED FLIGHT INSTRUMENT PANEL. C. Svimonoff. A 163-page report on a new flight-instrument panel which presents in a fully-integrated and readily-interpretable manner, all information required by the pilot for the successful accomplishment of his mission, including the newly required command information. The new panel represents the first application of the system approach to the total flight-instrument area. (Order PB 151541 from OTS, U. S. Department of Commerce, Washington 25, D. C.; price: $3.)

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## BOOKS RECEIVED

DICTIONARY OF GUIDED MISSILES AND SPACE FLIGHT. G. Merrill. *Van Nostrand*, 1959. 688 pp. $17.50. This illustrated dictionary covers the broad field of sciences associated with missiles and space flight. In numerous instances, definitions are followed by more extensive information of supplemental nature. Formulas, line diagrams and schematic drawings are provided throughout to explain fundamental concepts. A comprehensive cross-referencing system is used for linking related terminology.

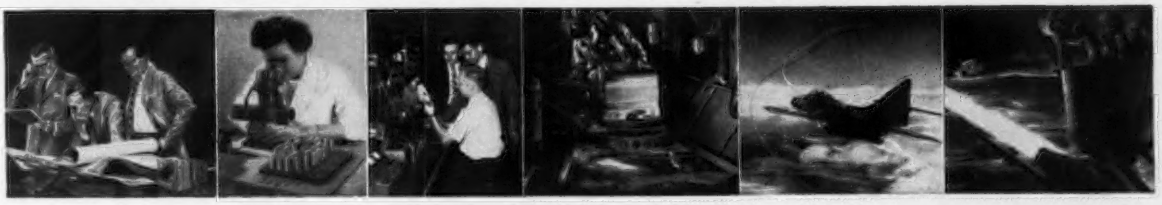
Cross-referenced items are printed in bold-face type so that the reader may turn to the corresponding entry for additional information. Terms having multiple definitions are also cross-referenced. Among disciplines treated are physics, chemistry, electronics, aerodynamics, astrodynamics, astronomy, and mathematics.

ANALYSIS AND DESIGN OF AIRCRAFT STRUCTURES. E. F. Bruhn and A. F. Schmitt. *Tri-State Offset Co.*, 1959. Vol. I, 482 pp. $8.75. This text book and standard reference for aircraft stress analysis, since 1943, has been revised and amplified into two volumes. Both volumes bear the same over-all title, accompanied by a descriptive sub-title for each. The sub-Stress and Strain," and for Volume II (in preparation), "Strength Analysis and Design." General contents of Volume I include: statically determinate structures; theory and methods for solving statically indeterminate structures; beam bending and shear stresses, member stresses, combined stresses; introduction to practical aircraft stress analysis. Appendix A covers elementary arithmetical rules of matrices. In addition to the coverage offered in the previous printing, Volume I features a chapter on the analysis of special wing problems, and one on the structural analysis of a delta wing by the "method of displacements." Illustrative diagrams, problems and solution are presented throughout.

PHYSICAL LAWS AND EFFECTS. C. F. Hix, Jr. and R. P. Alley. *Wiley*, 1958, 291 pp. $7.95. This is a conveniently arranged catalog of both familiar and unfamiliar scientific laws and effects. It is a useful cross-referenced compilation of information for engineers and scientists engaged in the solution of technological problems. It can serve effectively as a thought simulator through reference to some little-publicized phenomena of nature. To facilitate systematic searching, the information is presented as follows: alphabetical index of physical laws and effects; description of the laws and effects, with an illustration of application, and indication of the expected magnitude, references for additional information, and quantities; cross reference by physical quantities, listing also other quantities covered by the same law; and cross references by fields of science.

**New horizons in infra-red... by Bulova**

**Bulova designer-engineers can help you from concept to production**



Bulova infra-red, camera, TV and radar techniques are being combined with Bulova analysis and display systems for defense and industry.

Bulova infra-red R & D extends to fire control systems, filters, reticles and thermistor bolometers, as well as advanced work in mosaic and photoconductor cells. Here is a proven capability ready to assist you in any area of IR development from black body emanations through detection to final display.

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BULOVA

**Honeycomb Sandwich**

Brochure E—Honeycomb Sandwich design data.

Brochure D — Supplementary brochure with detailed honeycomb data.

*Hexcel Products*

**Circle 95 on postcard for more data**

**Welding Booklet**

Booklet, "How To Weld U. S. Steel's T-1 Steel," includes a heat input calculator for use in welding.

*U. S. Steel Corp.*

**Circle 96 on postcard for more data**

**Silver-Zinc Batteries**

Design details for over twenty new manual and automatically activated silver-zinc primary batteries.

*Cook Batteries*

**Circle 97 on postcard for more data**

**USS 301**

Data sheets on USS 301 stainless steel for aircraft and missiles.

*U. S. Steel Corp.*

**Circle 98 on postcard for more data**

**Ultrasonics**

12-page ultrasonic cleaning primer.

*National Ultrasonic Corp.*

**Circle 99 on postcard for more data**

**Electronic Facilities**

Brochure shows design, manufacturing, testing facilities.

*Dalmotor Div.*
*Yuba Consolidated*

**Circle 100 on postcard for more data**

**Specialty Steel**

40-page guide to firm's specialty steels.

*The Carpenter Steel Co.*

**Circle 101 on postcard for more data**

**H-11 Steel**

24-page booklet gives full data on type H-11 high strength steel for aircraft and missiles.

*Allegheny Ludlum Steel Corp.*

**Circle 102 on postcard for more data**

**YIG**

Bulletin on growth of single crystal Yttrium Iron Garnet for solid state amplifiers.

*Linde Co.*

**Circle 103 on postcard for more data**

**Superalloys**

Bulletins on vacuum induction melted UDIMET 700 and UDIMET 41 superalloys.

*Metals Div.*
*Kelsey-Hayes Co.*

**Circle 104 on postcard for more data**

**"Fail-Safe" Annunciator**

Bulletins describe operation of industrial process alarm system.

*Panalarm Div. of Panellit Inc.*

**Circle 105 on postcard for more data**

**Engineering Career Guide**

Basic information about eight major engineering activities and the kinds of persons usually successful in each. For critical self evaluation.

*Flight Propulsion Div.*
*General Electric Co.*

**Circle 106 on postcard for more data**

**Facilities**

Six-page Bulletin 5902 on firm's Materials Evaluation Div.

*United States Testing Co.*

**Circle 107 on postcard for more data**

**Corrosion Chart**

Wall chart provides comparative corrosion resistance of zirconium, titanium, tantalum, Hastelloy "C", and stainless 316 tubing to 43 commonly encountered reagents.

*Damascus Tube Co.*

**Circle 108 on postcard for more data**

**I.G.W. Avionics**

Avionics Dept. described.

*Indiana Gear Works*

**Circle 109 on postcard for more data**

**Time-Temperature Conversion**

"Conversion Charts For Time-Temperature Parameters" represent method of converting stress-rupture test data to a parameter.

*Aviation Gas Turbine Div.*
*Westinghouse Electric Corp.*

**Circle 110 on postcard for more data**

**Metal Ceramic Headers**

Recently developed line described.

*Radian Labs.*

**Circle 111 on postcard for more data**

**Metals**

Bulletin 109 presents data on RA309 metal used extensively where heat or corrosion is a problem.

*Rolled Alloys Inc.*

**Circle 112 on postcard for more data**

**Tool Steel**

Booklet on high-carbon, high-chrome, air and oil-hardening tool steel, "TRI-TUNG."

*Uddeholm Co. of America*

**Circle 113 on postcard for more data**

**Titanium alloy**

Heat-treatable titanium alloy, Ti-4Al-3Mo-1V for high speed aircraft treated in new engineering bulletin.

*Titanium Metals Corp. of America*

**Circle 114 on postcard for more data**

**Aluminum Alloys**

Technical brochure outlines properties of Olin Aluminum alloys in pig, ingot, and billet forms.

*Henning Brothers & Smith Inc.*

**Circle 115 on postcard for more data**

**Space Age Capabilities**

24-page facilities brochure describes space-age capabilities.

*Vap-Air*
*Div. of Vapor Heating Corp.*

**Circle 116 on postcard for more data**

**Copper-Base Casting Alloys**

Reprint of discussion of properties before American Society for Testing Materials.

*Brass and Bronze Ingot Institute*

**Circle 117 on postcard for more data**

**Anti-Collision Lights**

Specs on Madsen Xenon gas filled bulbs for aircraft.

*Sky Data Div.*
*Aircraft Engineering & Maintenance Co.*

Circle 118 on postcard for more data

**Precision Ground Steels**

16-pg. catalog on precision ground tool steels.

*Peninsular Steel Co.*

Circle 119 on postcard for more data

**Skydart I**

Sheet gives operation capabilities, and general details of Skydart I rocket-powered target.

*Santa Barbara Div.*
*Curtiss-Wright Corp.*

Circle 120 on postcard for more data

**Servomotors**

Comprehensive details of Beckman Size 15 Servomotors.

*Helipot Div.*
*Beckman Instruments*

Circle 121 on postcard for more data

**Silicol**

Price sheets on firm's silicone rubber in sheet form.

*Colonial Rubber Co.*

Circle 122 on postcard for more data

**Synchros**

Illustrated 170-pg. catalog of synchros, servo motors, servo amplifiers, resolvers, rate gyros, potentiometers.

*Ketay Dept.*
*Norden Div.*
*United Aircraft Corp.*

Circle 123 on postcard for more data

**Target Simulation**

Complete description of equipment in Controllable Radar Target Simulator.

*System Development Corp.*

Circle 124 on postcard for more data

**Thermocouples**

Catalog EN-S2 on full line of thermo-couples.

*Leeds & Northrup Co.*

Circle 125 on postcard for more data

**Titanium Machining**

32-page illustrated manual.

*Titanium Metals Corp. of America*

Circle 126 on postcard for more data

**Columbium Tubing**

Special analysis memo. no 121 deals mostly with applications of columbium with some details on tantalum and vanadium tubing.

*Superior Tube Co.*

Circle 127 on postcard for more data


Waugh transistorized

PULSE RATE CONVERTERS

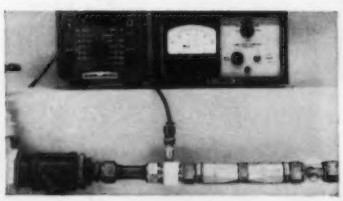
Waugh FR-300 Series Pulse Rate Converters are being used in aircraft, missiles, ground support and instrumentation systems for flow, tachometer and frequency measurement applications.

All models utilize transistors and magnetic circuitry exclusively, resulting in exceptionally high stability, low power consumption and compact size. Components operate well below their rated capacity assuring complete reliability and longer life.

Model FR-302 is a frequency-to-DC converter, producing DC voltages which are directly proportional to the frequency of the AC input signal. The FR-303 is a frequency-to-DC converter with zero suppression, providing full scale output signals over narrow input frequency ranges. The 302 and 303 are particularly suited to airborne operation and will work in conjunction with 0-5 volt DC oscillators for telemetering applications. Model FR-305 is a direct reading frequency indicator, combining an indicating meter with the circuitry of the FR-302 in a single instrument for visual readout applications.

All models are available with modifications of input and output characteristics and frequency ranges.

*For Detailed Information Write for Bulletin 103*



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Waugh

# industry notes

Titanium-alloy bands (Ti-6AL-4V) are riveted at 18 inch intervals around DC-8 forward section to guard against crack propagation.

Castor oil, heated to 100° F, keeps air from being trapped inside electronic transducer assembly being covered with rubber shells at Martin Co.

Closed die forging is checked at Alcoa, Cleveland, before shipment to Lockheed.

Rocket-fuel container, of new precipitation-hardening AM-355 stainless steel, is strain-tested at The Budd Co.

Hydro-Air "flying platform" nears completion at Spacetronics Inc.

## MULTIPLE PAYLOADS?

NASA may launch multiple satellites in single firings, according to Edgar Cortright, chief of programs, advanced design, for the Agency. He stated:

"Plans are underway to use large payload capabilities for multiple experiments, perhaps even multiple satellites."

Both polar and stationary equatorial satellites are eventually planned under communication satellite program, he added. Inflatable aluminized-mylar balloon to be launched in early 1960, is 0.005 in. thick, weighs 150 lb. Microwave signals are reflected both ways off the satellite between Bell Telephone's Holmdel, N. J. facility and NASA's Goldstone, Calif. station.

Planners envision manned circumnavigation of moon after experiments with manned orbits. In plans, the manned lunar probes would take place in less than 10 years if boosters in Saturn size were developed speedily.

## F-108 CANCELLATION

North American Aviation has indicated that, because of Air Force cancellation of F-108 development, it will probably

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. . . . plasma and ion power sources for rockets and space vehicles; VTOL powerplants. (Flight Propulsion Laboratory Dept.)

. . . . developing production techniques for unusual materials and design configurations (Production Engine Dept.)

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**FLIGHT PROPULSION DIVISION**

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*Cincinnati 15, Ohio*

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assume some B-70 work previously subcontracted.

B-70 subcontractors include Boeing (wing), Lockheed (fuselage section), and Chance Vought (horizontal and vertical stabilizer sections).

## ARPA PLANS TRANSFER OF SPACE PROJECTS

The Midas, Samos, Transit, and Notus satellite systems may remain in ARPA's fiscal '61 budget.

Plans for transfer of these ARPA space-projects were announced recently. Actual transfers are not expected for a year to two years from now. Interval would be used for coordination between the agency and the new developer-operators.

ARPA now has a new, classified project involving earth and space environments. This gives it five general areas: materials research, military space technology, advanced missile defense, solid propellant research, and the secret project.

The transfer plan recalls the agency's charter to engage in and supervise advanced research projects with one aim being "to facilitate early operational assignment."

Planned shift gives the Air Force responsibility for development, production and launching military space boosters; except for the Saturn booster; and for developing Midas early warning satellite and Samos reconnaissance satellite. Navy was assigned Transit navigation satellite system. Army will develop Notus satellite-borne communications system.

---

Officers of the seven self-governing divisions of SAMPE (Society of Aircraft Materials and Process Engineers) will meet in Los Angeles during Western Division's Sealant Symposium to discuss organizing on a national basis.

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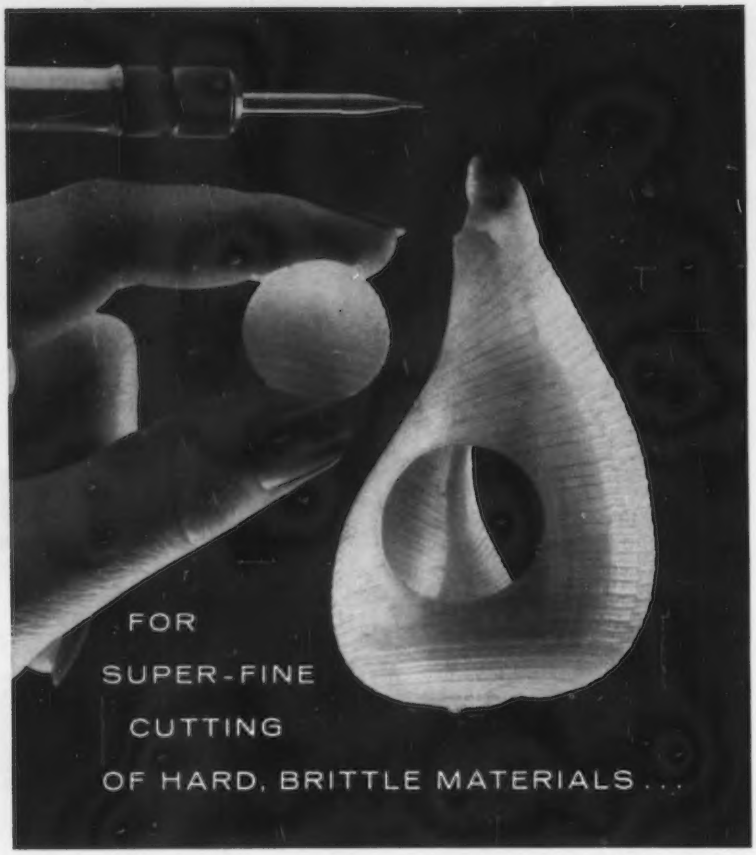


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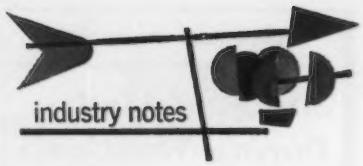


## CONTRACTS . . .
## . . . PROCUREMENT

Western Electric received a $188,402,905 Army contract for R & D on the **Nike Zeus** anti-missile systems; and got an additional $10,995,680 from the Army for Nike Hercules.

The Air Force awarded American Bosch Arma $53,350,000 for advanced lightweight versions of **Atlas all-inertial guidance system.** Funds also cover additional systems besides present one. Air Force gave American Machine and Foundry $42,600,000 to build the first 18 operational launching systems for Titan.

The Army gave Martin-Orlando $24-million for **Pershing** development; and Raytheon $30,162,502 for **Hawk.** Bulk of latter contract is for ground support.

Aerojet-General received an $8-million subcontract from Grumman to develop rocket power plant for the **Eagle.**

In aircraft, Navy contracts included:

- $137,600,000 to McDonnell for **F4H-1 jets.**
- $67,800,000 to Lockheed to begin producing **P3V-1** ASW planes; $19,110,000 to Lockheed for 26 **P2V-7** Neptunes.
- $9,500,000 to Chance Vought's Aeronautics Div. to incorporate technical advances in 164 **Crusaders.** Program stretches through February, 1961. Firm said a new order for the F8U-2N will exceed $25-million.
- $11,355,000 to Aviation Gas Turbine Div., Western Electric, to produce the **J34-WE-48** jet engine

# AIRCRAFT AND MISSILES industry orbit

## AIRCRAFT

### DESIGN

Vertol is wind-tunnel-testing a model of new design ground support vehicle at James Forrestal Research Center, Princeton, N. J. . . . Spacetronics Inc. unveils their tear-drop-shaped air-cushion prototype this month. Design utilizes horizontally rotating propeller and plenum chamber. . . . The PT-6, 250 lb 500 hp free turbine engine being developed by Canadian Pratt & Whitney Aircraft, is designed for single and multi-engined planes, helicopters, and VTOL craft. Conventional engine layout is reversed, avoiding concentric shafting.

### DEVELOPMENT

Report of the Research and Development Subcommittee of the Joint Committee on Atomic Energy said that flying a nuclear-powered plane as early as possible is "in the national interest." It advocated continued emphasis on developing advanced materials concurrent with any programing to achieve early flight with available materials. Report cited "recent technical advances" in the indirect cycle system, urging continued effort. . . . Pratt & Whitney is pursuing indirect cycle work at Middletown, Conn. . . . The AEC said General Electric will continue development of the X-211 direct cycle system but with increased emphasis on developing more advanced fuel elements for a higher performance powerplant. . . . Lycoming will develop the T-55 shaft turbine engine through its 150 hr qualification test under new Air Material command contract. . . . The Bell X-14 VTOL plane is now at NASA's Ames Research Center for more flight testing. . . . Lockheed's Jetstar is the Air Force choice as a bombardier-navigator jet trainer; it was chosen over McDonnell's Model 119-A.

### PRODUCTION

Vertol begins assembling the YHC-IB "Chinook" this month, mockup review scheduled for January. . . . Piasecki is producing its second "flying jeep" which will be powered by two instead of one gas turbine. Rollout is expected by the end of January. . . . LaPointe Machine Tool Co. has built a 340 inch helicopter spar broaching machine. It broaches the inside contour of a 24 ft spar using a conveyor system and over 30 broaching tools. Final pass leaves finish better than 50 micro-inch. . . . Cancellation of the F-108 program is attributed to DOD decision to cut programs regarded as "marginal." B-70 shapes up as the "all-purpose" plane carrying the air-launched missiles which are one reason for demise of the F-108.

## MISSILES

### DESIGN

Test firings of a Minuteman "live" first stage and dummy second and third stages are underway at Edwards Air Force Base. Missile is tethered with 2000 ft. of nylon cable since tests aim mainly at investigating design of the operational Minuteman launch silo. . . . Satellite powerplant proposed by Allison Div., General Motors, includes Stirling-cycle engine of one cubic inch displacement capable of producing 1½ hp. A lab model was recently operated on solar energy with plastic 20 ft. diam. Fresnel lens concentrating sun's rays on a window in engine's heat trap. . . . Vanguard III went into orbit attached to Allegheny Ballistic Laboratory X-248 solid propellant rocket rather than usual Grand Central X-242 third stage. . . . ABMA is supporting studies of acoustic vibration problems affecting design of the launching pad for the 1.5 million-lb.-thrust Saturn. . . . Martin is investigating application of its portable reactor systems as independent power sources for hard-based missile sites, and as power under vacuum conditions of the moon. . . . Douglas holds the contract for preliminary design of air-launched missile which could have anti-satellite applications.

### DEVELOPMENT

Firings of final series of Polaris test vehicles are underway at Cape Canaveral and will continue through the Spring. . . . Failure of the first Transit 36 inch, 265 lb. navigational satellite is laid to non-firing of third stage of Thor Able launching vehicle. . . . Martin's Nuclear Div. is testing five SNAP III power generators to see how the generator housing would take shock and vibration of a multi-stage rocket. Both when fueled with radioisotopes and electric battery heaters, generators dipped in power output under vibration. Output did not dip under centrifuge loads of 15 g's—equivalent to rocket launching loads. . . . Martin is now developing an isotopic tube heater for WADC. It cuts weight of battery pack used in rockets or space platforms. . . . Ryan Aeronautical will build at least one solid rocket chamber, sub-scale for test purposes, of titanium. . . . Wyman-Gordon is applying a new beryllium-forging process to approxiately ten development configurations. Process has forged a 160 lb hollow beryllium part which is being tested. . . . Rocketdyne's Dr. Robert H. Boden, who engineered prototype ion thrust device, says flyable ion engine could be ready within five years. . . . With control of Saturn Project by NASA instead of the Army almost certain because of presidential backing, Agency says it will keep von Braun team of scientists intact at Redstone Arsenal. . . . Air-launched two-stage missile which reached near Explorer VI orbit last of ten vehicles which Martin built in Bold Orion development. . . . Nike Zeus anti-missile missile was fired at White Sands with series of technical-appraisal tests slated through Spring.

### PRODUCTION

Casing for Atlas Able IV solid propellant third stage was produced by filament winding technique developed over a ten year period at Hercules Spring Div. of Hercules Powder Co. Fiberglass filament is impregnated with epoxy resin and casing has strength-weight ratio four times that of steel. . . . Pratt & Whitney Div. of United Aircraft is now operating a new Floturn machine built to P & W specs by Lodge & Shipley. Believed the largest in the world (over 300,000 lb.) it is making experimental solid fuel rocket cases, can produce a piece 80 in. wide, 30 ft. long. The installation, which took 18 months from design to installation, permits seamless and weldless design. . . . Ryan Aeronautical is developing a welded strip-winding technique along with its work on Polaris solid rocket chambers. Thin sheets of steel are wound around a mandrel, tackwelded, and then spotwelded to create the desired wall thickness. ◆

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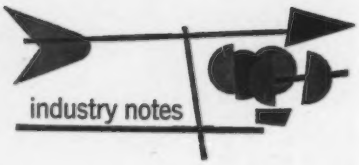



## FACILITIES . . .

**Standard Pressed Steel Co.** is doing experimental work on beryllium fasteners in building it has acquired near its main plant.

**Astro Metals Corp.**, Hawthorne, N. J., is building special facilities for its new beryllium components division. They will aid Astro's NASA-supported project to study refractory metals of critical importance to reentry problems.

**Sylvania Electric Products** plans completion of new 6,000 sq. ft. structure, for fabricating refractory metals, early next year.

**American Metal Climax Inc.** will build a new germanium refining plant at Carteret, N. J.—full operation expected next year.

**AC Spark Plug** is adding 215,000 sq ft to its Oak Creek, Wisc. missile guidance plant.

**Giddings & Lewis Machine Tool Co.** has acquired a substantial interest in **Nassovia Werkzeugmaschinenfabrik G.m.b. H.**, German machine tool producer.

**Norden Div., United Aircraft,** is building multi-million-dollar engineering research and manufacturing facility in Norwalk, Conn.

**Tapco Group of Thompson Ramo Wooldridge** has three new buildings slated for completion early next year in Anaheim, Calif. for research, development and manufacture of aircraft and missile products.

**Bendix Aviation's** semiconductor products plant is slated for completion next year.

**F. J. Stokes Corp.** breaks ground this month for a 50,000 sq. ft. addition for high-vacuum processing.

**Lear, Inc.** is operating a new 172,800 sq. ft. plant housing all the manufacturing activities of its Instrument Div.

**Chance Vought** is installing 90 per cent new equipment in its heat treating facility in a $1-million modernization to handle exotic metals.

Master Control Center planned by **Lockheed Missile and Space Div.** at Mountain View, Calif. will integrate world-wide satellite-tracking information. It will include closed circuit tv views from Vanderburg AFB site 250 miles away. It will have important functions in monitoring Samos reconnaissance satellite system.

**Hughes Aircraft** has formed an Advanced Program Development Operation within its Airborne Systems Group to "keep pace with the growing complexities of modern weapons systems."

**North American Aviation** has added a $140,000 deep freezer to its Columbus, O. plant. Built and installed by Tenney Engineering Inc., it is capable of —120 deg. F, will be used in a new method of fabricating supersonic wing sections by honeycomb brazing.

**Metals Div., Kelsey-Hayes Co.,** has installed a 5,000 lb. high vacuum induction furnace. Reported as "significant breakthrough in vacuum metallurgy," it reportedly makes feasible vacuum induction furnaces of 10,000 lb. and 20,000 lb. capacities.

**North American Aviation** has completed purchase of full interest in **Astrodyne Inc.**, whose solid propulsion operations will be continued as part of the Rocketdyne Div.

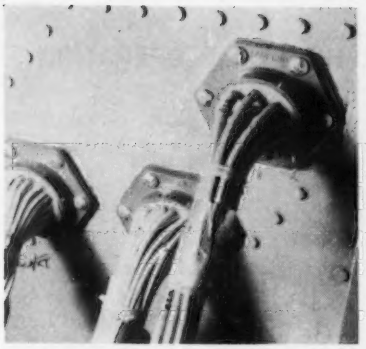
**Chemical Milling International Corp.** has been issued the patent for contouring honeycomb core by chemical etching.

**Douglas Aircraft** expects to operate an RW-300 digital control computer in early 1960.

**Whittaker Engineering Laboratories, Telecomputing Corp.,** has a new method of testing gaseous oxygen relief valves in X-15 LOX system. Valve is attached to 5,000 force pound shaker. Cycling oscillator excites it through full range of frequencies as temp drops.

**Linde Co.,** div. of Union Carbide, expects to operate a new plant, for liquid oxygen-nitrogen production, in about a year near Neosho, Mo.

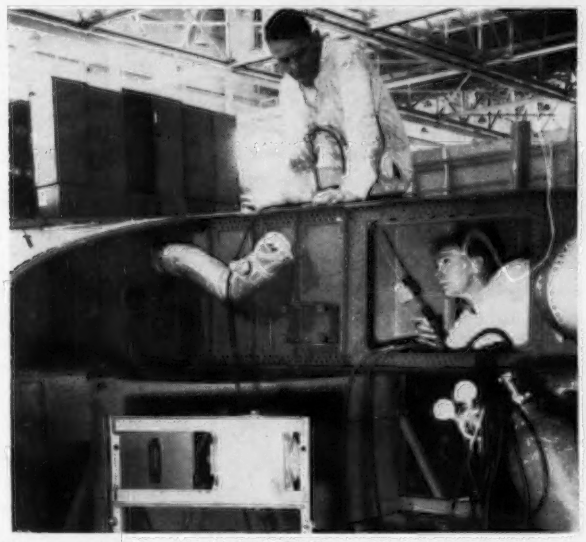
# *many products . . . many fields*



In Convair 880 pressurization system, electrical wiring from cabin passes through Burndy Corp. sealed bulkhead panels.

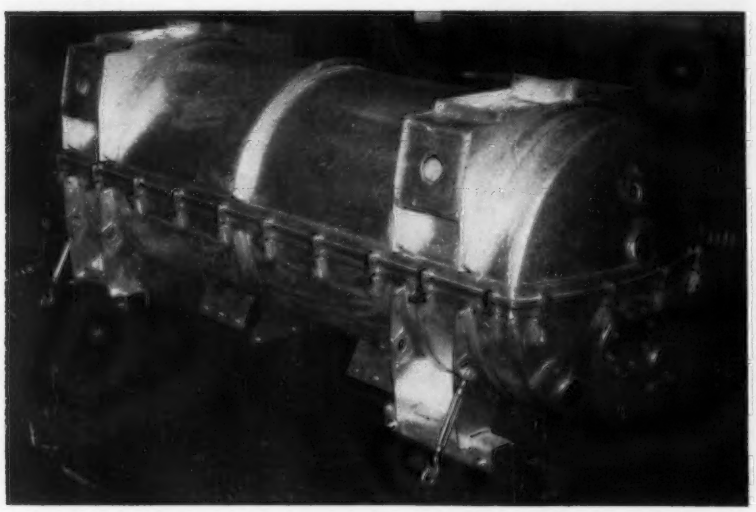
Inner throat of rocket's graphite nozzle insert is machined to within plus or minus six thousandths of an inch at Cleveland plant of National Carbon Co.

Infrared analyzer locates minuscule leaks in wing tanks at Martin Co. Nitrous oxide, injected from outside, moves to leak source, actuates neon light on Perkin Elmer analyzer inside wing.



Reusable 580 lb shipping container protects 500 lb missile from —65°F to 160°F under shock of 25 g's. It is aluminum 6061-T6 alloy .081 in. thick. Ludwig Honold did design and fabrication. General Electric developed specs and designed shock mount system.

Engineer appears lost amid giant blades used in turbine



Seven-ton radar antenna for SAGE in final assembly at the General Electric Ordnance Dept.

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## RESISTANCE WELDING FOR HIGH-TEMP OPERATION

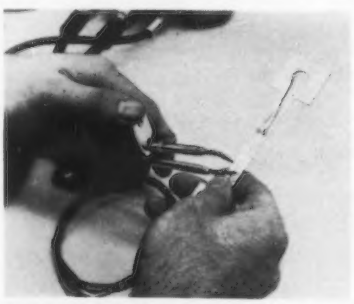
by Gerald E. Woods, General Manager
Weldmatic Div., Unitek Corp.

In many phases of missile construction and testing, resistance welding is replacing bonding or soldering techniques. Result is increased reliability at high temperatures. These operations include welded honey-comb structures, thermocouples, strain gages, and high-temperature transducers.

Because resistance welds are a direct fusion of the parent metals, such connections will withstand temperatures approximating the melting point of the metals themselves. Therefore, heat limitations are established by the parts being welded — not by the connections or joints.

An example is thermocouple wires. Chromel-Alumel and platinum, platinum rhodium resistance-welded junctions consistently withstand extremely high temperatures.

Another example, is stainless steel honeycomb sections. Rheem Manufacturing welds these to edge members with brazing foil sandwiches in between. Positioning is easier, faster, with no chance for change before brazing is complete. Up to five layers of stainless steel and brazing foil are welded at one time.



**Convair welds "difficult" metals for thermocouple assembly with tweezer handpiece.**

In the Convair B-58 flight-test program, hundreds of unique high-temperature pick-ups constructed through resistance welding were used to measure the dynamic and static pressure differential on airfoil surfaces. Consolidated Electrodynamics' Transducer Division, the manufacturer, is also using resistance welding in new designs aimed for extremely high temperature operation.

Resistance welding equipment for these operations consists basically of a capacitor-discharge power supply and the electrodes, which may be either in permanent fixtures or in handpieces. Capacitor-discharge welders draw energy from standard line sources at a low level. This voltage is stepped up, rectified, and stored in the capacitor bank. When the weld circuit is closed, a large quantity of energy flows through the primary of the pulse (welding) transformer and a secondary welding current of high peak is produced.

The real secret to exceptional high-quality welding is an extremely short current flow or "pulse width." The large burst of energy, which lasts only milliseconds, permits complete fusion to occur between the metals involved. But heat transfer with its side effects of deformation and discoloration cannot occur.

So-called "difficult" metals are welded easily with this method. Convair assembles iron-constantan thermocouple leads to low-carbon steels, aluminum alloys, and magnesium alloys, with complete reliability.

The millisecond spot-welding principle also finds a great deal of use in ultra-fine work, including work done under binocular microscopes and with tweezer-type welding handpieces.

**Moving furnace brazes 16-ft-long honeycomb wing spar at Solar Aircraft. Designed and built by Solar, it brazes at up to 2000°F. All-metal honeycomb structure is sealed into mandrel and placed on T-bars.**

## PRODUCTION TECHNIQUES

**Lapointe Machine Tool Co.** has built a 340 inch helicopter spar broaching machine. It broaches the inside contour of a 24 ft spar using a conveyor system and over 30 broaching tools. Final pass leaves better than 50 micro-inch finish.

**Lockheed Aircraft Service** is using Picker X-Ray Iridium 192 unit to inspect inaccessible sections of aircraft. Radio-active source penetrates three-inch-thick metals.

**Navy** technique to determine sparking characteristics of metals is described in OTS report PB 151650.

**Corning Glass Works** is forming fused silica into new shapes and sizes by adaptation of its Multiform process.

To machine six-ft.-high 3,000 lb aluminum castings, **Pratt & Whitney Aircraft** has added an operators platform - lift to Bullard vertical turret lathe.

**Harvey Aluminum** has extruded a hollow aluminum shape measuring 24.190 x 2.485 inches on a 12,000 ton hydraulic press. Reportedly the largest multiple hollow shape ever extruded, six hole shape functions as a containing unit in electronic control system.

**E. W. Bliss Co.** is using special forming techniques on aluminum plate for the 15,000-sq.-ft., 140 ft. diam. parabolic dish of the Green Bank, W. Va. radio telescope. Firm uses epoxy resin dies to keep within 1/16 of an inch of perfect parabolic shape.

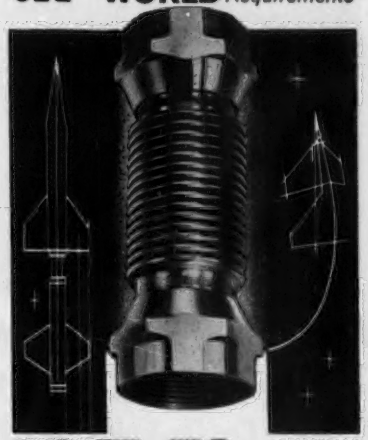
**Boeing** is welding 3/32-in. steel balls to specimens being tested for temperature resistance, tensile strength. Balls attach to sockets on extensometer arms, eliminating slippage of conventional clamping.

New "Chem-Size" process, now in production use at **Anadite Inc.**, resurfaces hot rolled stainless steel previously considered unusable because of poor surface conditions. Process is being used on single 12 ft. x 25 ft. parts.

To test missile components under re-entry heat, **Selas Corp. of America** built 6 million BTU per-hr., 3,000 deg F gas air burner for a missile manufacturer.

Aerojet-General is using a 75-ton LeBlond double bed lathe at Azusa. Used with firm's AeroWRAP process of fabricating large pressure vessels, lathe is 54 ft six in. long and 120 inches wide.


**up to OUT-OF-THIS WORLD** *Requirements*



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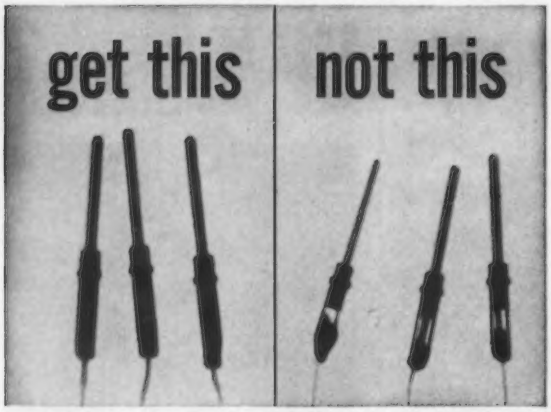


## Actual X-ray Photos Show How IDEAL Thermo-Tip Resistance Soldering Tools Reduce Costly Voids in Winchester and Cannon Plug Pins

*Because the whole pin is heated, "cold-flow joints" are eliminated; failures are greatly reduced*

| Pin No. | Conduction Method: Length of void | Conduction Method: % of void | Resistance Method: Length of void | Resistance Method: % of void |
|---|---|---|---|---|
| 1 | 0.12″ | 40 | 0.00″ | 0 |
| 2 | 0.12″ | 40 | 0.00″ | 0 |
| 3 | 0.07″ | 23 | 0.05″ | 17 |
| 4 | 0.18″ | 60 | 0.00″ | 0 |
| 5 | 0.06″ | 20 | 0.06″ | 20 |
| 6 | 0.05″ | 17 | 0.04″ | 13 |
| 7 | 0.02″ | 7 | 0.05″ | 17 |
| 8 | 0.08″ | 27 | 0.01″ | 3 |
| 9 | 0.09″ | 30 | 0.07″ | 23 |
| 10 | 0.12″ | 40 | 0.09″ | 30 |
| 11 | 0.15″ | 50 | 0.04″ | 13 |
| 12 | 0.12″ | 40 | 0.06″ | 20 |
| 13 | 0.09″ | 30 | 0.01″ | 3 |
| 14 | 0.12″ | 40 | 0.08″ | 27 |
| 15 | 0.11″ | 37 | 0.02″ | 7 |
| 16 | 0.10″ | 33 | 0.04″ | 13 |
| 17 | 0.07″ | 23 | 0.04″ | 13 |
| 18 | 0.09″ | 30 | 0.09″ | 30 |
| 19 | 0.11″ | 37 | 0.10″ | 33 |
| 20 | 0.11″ | 37 | 0.06″ | 20 |
| 21 | 0.05″ | 17 | 0.01″ | 3 |
| 22 | 0.15″ | 50 | 0.00″ | 0 |
| 23 | 0.11″ | 37 | 0.05″ | 17 |
| 24 | | | 0.07″ | 23 |

● These production test results from a major Aircraft manufacturer prove the superiority of Ideal Resistance Soldering Tools to the best available commercial soldering irons. Voids averaged 33% with soldering irons. With resistance soldering only 14%.

In addition, higher production speeds were possible on Cannon plugs and operators were less subject to painful burns. Send for descriptive literature.

IDEAL INDUSTRIES, Inc., 1390-K Park Ave., Sycamore, Ill.

Gentlemen: Please send complete catalog information about Ideal's Thermo-Tip Resistance Soldering Tools.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

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## CUT PRODUCTION COSTS..

with an Air-Speed TRADE MARK PNEUMATIC

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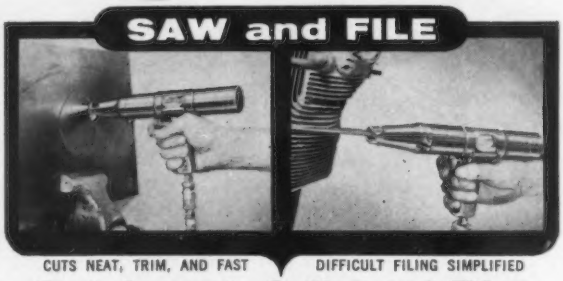

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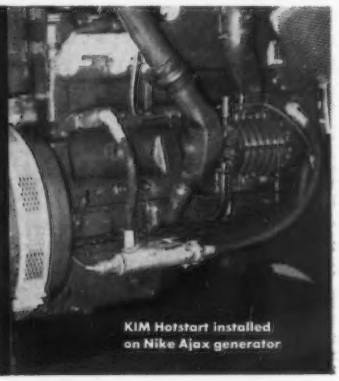
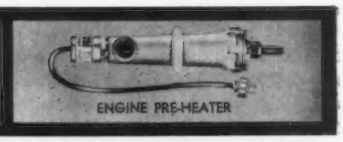
## KIM HOTSTARTS keep U.S. NIKE AJAX on all-weather ALERT!




When efficiency is measured in split seconds, "cold starts" must be eliminated. That's why Nike Ajax are now equipped with KIM Hotstart engine pre-heaters. Regardless of weather, they enable operation under full load within seconds. For details on KIM Hotstarts, see your automotive dealer or write us for free literature.

KIM Hotstart




**KIM HOTSTART MANUFACTURING CO.**

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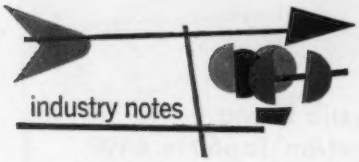


## NAVY LAB STUDIES ACRYLIC LAMINATES

Attempts to increase physical properties in glass-cloth reinforced, plastic laminates has brought some attention to diisocyanate resins. Preliminary studies recently completed at Naval Air Material Command (NAMC), Philadelphia, indicate that the resins can be used to give room temperature physicals which exceed the requirements of specifications covering polyester, epoxy, and phenolic laminates.

Resins formulated from glycols containing a chain of 4 carbon atoms produced consistently superior mechanical properties. Pot life is about 4 hr at room temperature. Future work will therefore center on these resins and will include attempts to increase resistance to combustion, and resistance to deformation at 300°F. Extended studies will also measure the effects of gamma radiation.

Close attention to the control of the reaction exotherm was essential in establishing a formulating procedure for consistently "strong" resins. Reacting glycol was added dropwise into refrigerated resin. Mechanical stirring was used to prevent complete change of state in the diisocyanate. Benzene was also used to retard polymerization, once exotherm was initiated.

Some average results are shown in comparison with existing specifications. (Ed. Note. Further information may be obtained from NAMC: Attn. A. P. Bonanni, project engineer.)

**REQUIREMENTS OF EXISTING SPECIFICATIONS**

| Government Specification | Resin | Specimen Thickness (in.) | Flexural Strength (psi) | E X $10^{-4}$ |
|---|---|---|---|---|
| MIL-R-7575A | Polyester | 0.125 | 50,000 | 2.50 |
| MIL-R-9300(USAF) | Epoxy | 0.125 | 70,000 | 3.20 |
| MIL-R-9299 | Phenolic | 0.125 | 50,000 | 3.00 |

**VALUES FOR POLYURETHANE RESINS**

| Formula Number | Glycol | Specimen Thickness (in.) | Flexural Strength (psi) | E X $10^{-4}$ |
|---|---|---|---|---|
| 33 | 2-Butene-1 4 Diol | 0.092 | 90,000 | 4.35 |
| 36 | 1, 4-Butane Diol | 0.089 | 92,000 | 4.14 |
| 30 | Diethylene | 0.087 | 100,000 | 4.17 |

**The TITAN "Target" STUD DRIVER**

**Engineered for the Aircraft and Precision Engine Industry**

The TITAN "Target" Hex Collet Stud Driver drives the stud by pitch diameter pressure instead of pressure on the top of the stud. This method completely eliminates mutilation and stretching of stud threads, and distortion of cotter key holes.

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Can be adjusted for various lengths of grip on the stud simply by lifting the clutch ring and screwing the collet holder farther onto the sleeve for a shorter grip or farther off the sleeve for a longer grip.

Furnished with either a ½" female square for mounting on air drills or with ¼"—16 female thread in top of driver. Morse Taper Shanks and Hex Shanks are available; also T-Handles for hand use.

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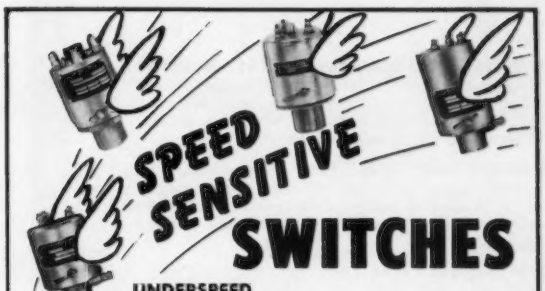


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One S.P.D.T. switch to trip at speeds as low as 400 RPM. Maximum operating speed 5,000 RPM.

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One S.P.D.T. switch to trip at speeds between 500 and 6,000 RPM.

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Two S.P.D.T. switches to trip at two different speeds between 500 and 6,000 RPM.

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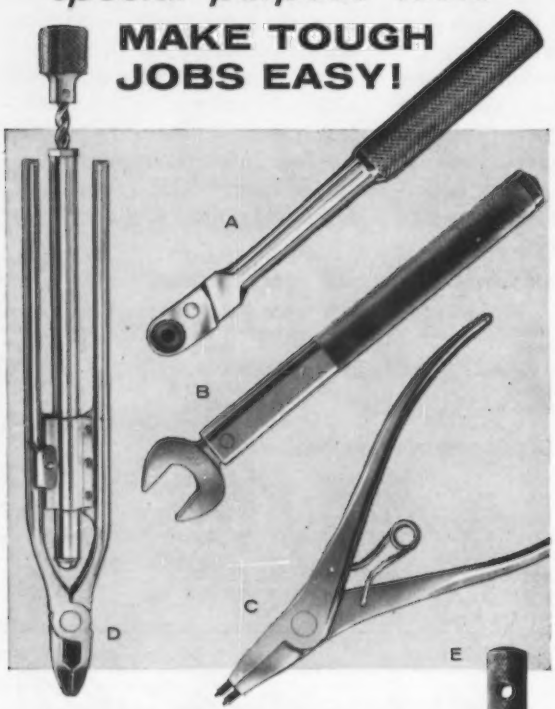


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**B. MILBAR SNAP TORQUE TOOL**—with pre-set torque. A "click" you can feel and hear tells when proper torque is reached. A choice of head types for specific jobs. Widely used on production lines in the automotive and aircraft industries.

**C. MILBAR SNAP RING TOOL**—the original and most widely used tool with replaceable points of different shapes and sizes. Tool lasts forever—just change points for the job at hand or when they wear out. Special points for holeless snap rings.

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## New Mystik Brand Super Flextron® Tape No. 6497 Has Bi-Directional Strength

**An unique packaging tape.** Super strength bi-directional filaments are an integral part of the product—providing equal strength in both directions. The tape is water and moisture proof. Excellent quick stick properties and it stays stuck.

TYPICAL APPLICATIONS: Strapping and holding heavy machinery parts—sealing heavy-content packages for shipment—holding loose parts in place for assembly of refrigerators and stoves—heavy banding on corrugated, fiberboard and wooden cartons—strapping tubes, rods and lumber—banding groups of cartons on pallets. Frequently replaces steel strapping.

(Conforms to Government Specifications PPP-T-97-Type 11)

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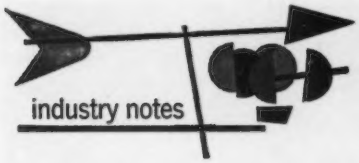



## SPACE LOG

**Oct. 4** — Lunik III fired into projected 15 day orbit around both the earth and moon. Passing estimated 4,375 miles from moon, it carries temperature regulating device, two radio transmitters, and possibly a camera. Estimated initial thrust —600,000 to 800,000 lb.

**Oct. 14** — Explorer VII (91½ lb.) placed in orbit by four-stage Juno II rocket. Apogee: 664 miles. Perigee: 346 miles. Chief purpose: study of the radiation now believed to be fluctuating bands starting about 480 miles above earth.

## OUTLOOK—MATERIALS

AEROJET - GENERAL reports that room temperature values exceeding 7500 psi tensile shear strengths have been obtained on titanium alloy B120VCA (Crucible) using FM-47 and Prebond 700 (Bloomingdale). Room temp values on 7075-T6 Al reached 4950 psi at 120°F; on 4130 steel, they reached 7100 psi at room temp. Factors increasing bond strength: pretreatment with Prebond 700, use of vinyl-phenolic primer (FM-47), evacuation of entrapped air, curing under 15 psi for powdered epoxy base adhesive (Epibond 100).

THIN refractory coatings used to protect metallic rocket nozzles have proven detrimental in protecting plastic nozzles. Gas builds up between plastic and refractory material, cannot escape fast enough, and explodes.

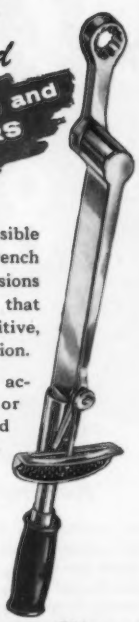
ALCOA has released findings from year-long research program on use of aluminum for solid propellant rocket motor cases. Firm reports that light metal cases in 7178-T6 aluminum alloy exhibited yield strengths equivalent on a weight basis to 224,000 psi in steel. Process, combination of forging, extruding, sizing and machining into one-piece case, is expected to produce cases with yield strength equivalent to 255,000 psi in steel.

BUREAU of Mines metallurgists produced molybdenum of 98 per cent purity and tungsten better

*continued on next page*

*Only* **ONE** *Torque Wrench can be accurately used with . . .*

**EXTENSIONS and ADAPTERS**



It is mechanically impossible to use any Torque Wrench with adapters or extensions (with accuracy) unless that Torque Wrench has a positive, built-in, fixed load position.

This essential factor of accuracy, misunderstood or ignored in the design and manufacture of some torque tools, can completely defeat their purpose.

**Patented pivoted handle fixes load position**

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with formulae tables and explanations for correct use of adapters and extensions.

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**to cut costs on the assembly line**

MODEL 400-RSP REVERSING SCREWDRIVER

MODEL 400-RN REVERSING NUTSETTER

Airetool pneumatic screwdrivers and nutsetters are easy to handle, easy to maneuver. And they have all the power it takes to speed up fastening operations. You get this same excellent power-to-weight ratio in Airetool lightweight sanders and die grinders, too. It will pay you to call your Airetool representative, or write us for Catalog 63.

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**CANADIAN PLANT:** Brantford, Ontario

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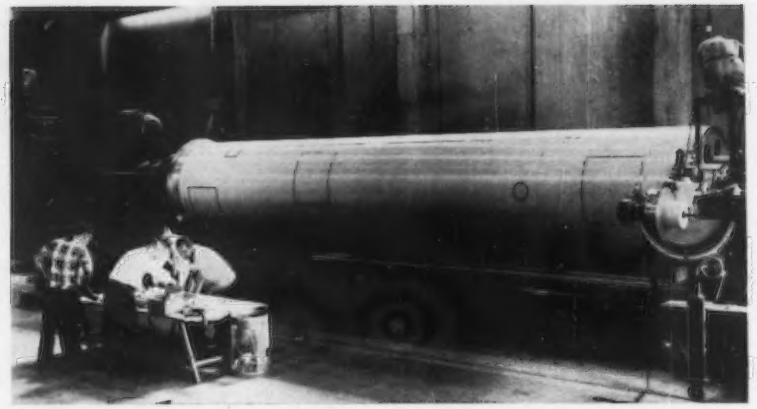
industry notes

**Outlook-Materials**
**(continued)**

than 99 per cent pure with process known as fused-salt-bath electrolysis. The powders were produced from scheelite concentrate mixed with alkali phosphates or borates.

ULTRA-PURE arsenic is reportedly moving into prominence for semi-conductor application. Besides III-V compounds, many arsenic derivatives are being evaluated.

USE of epoxies will jump to 25 million lb. by 1966, with a $50-million market, according to American Chemical Society.



**Reinforced plastic shipping container liner, 25 ft. long with 57 in. diam., is produced at Zenith Plastics Co., Gardena, Calif., for Lockheed Missiles and Space Div. Made of "Scotchply" material (Minnesota Mining and Manufacturing), it is believed the largest cylinder of its type, weighs less than 1,000 lb.**

DOW Corning reports facts of making silicone-epoxy copolymers from silicone resins and commercial epoxy resins. Copolymerization depends on reaction of silicone hydroxyl groups with carbinal groups. Standard epoxy curing agents can be used.

THE Flight Propulsion Laboratory Department of General Electric has developed refractory cerium sulfides for use in casting openings or channels in high temperature metallic materials. Applied in core form, they permit casting temperatures above usual.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MEASURES ONLY 4"x1½"x1½"

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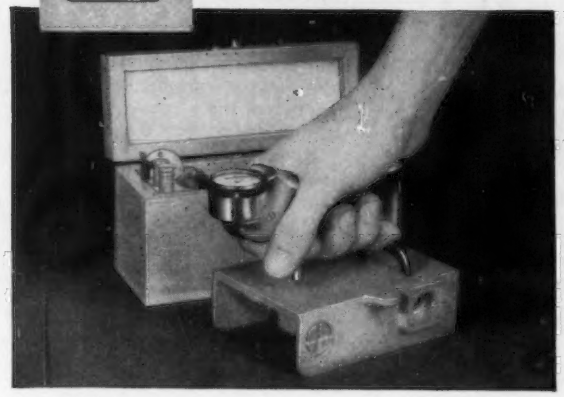
THE MARK OF QUALITY

BARBER COLMAN

# Impressor

**PORTABLE HARDNESS TESTER**

- Rapid testing—no setup
- Easy to carry and use
- Needs only space for hand



A portable hardness tester for aluminum alloys, soft metals, and plastics, the Barber-Colman Impressor is designed for fabricated parts and raw stock testing. Operating experience is not essential. The reading is instantly indicated on the convenient dial. No waiting, preloading, or separate measurements. Barber-Colman engineers will gladly recommend the most suitable model for your application. Write today for complete details.

**BARBER-COLMAN COMPANY**

Dept. W, 12109 Rock Street, Rockford, Illinois

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# PRECISION TUBE BENDING

MB experience ranges from bending simple tubes to fabricating complete assemblies like the fuel manifold shown, and includes machining and bending work with corrosive- and heat-resistant materials.

**Extensive facilities** devoted solely to tube bending are contained on three factory floors. Equipment includes hydraulic tube benders, presses, automatic and manual brazing and welding equipment.

**Aeronautical inspection** techniques involve X-ray, Zyglo, Magnaflux, hydraulic and pneumatic pressure testing equipment, when indicated, guaranteeing maximum reliability, performance from parts.

**Satisfied customers** are included in any list of leading manufacturers in aircraft-missile fields.

Write for MB facilities booklet —or for quotation.

**MB ELECTRONICS**

A DIVISION OF TEXTRON ELECTRONICS, INC.

1069 State St., New Haven 11, Conn.

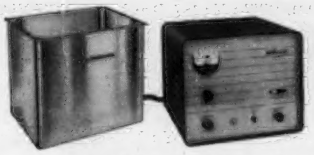
Circle 49 on Inquiry Card

# MAMMOTH narda SONBLASTER

*America's first mass-produced industrial-size ultrasonic cleaner!*

**SAVE** *7 ways over costly solvent, alkaline or vapor degreasing:*

**• Clean faster, speed production! • Cut rejects, eliminate bottlenecks! • Save on chemicals & solvents! • Eliminate expensive installation! • Cut maintenance and downtime! • Save on floor space! • Release labor for other work!**



G-1501 generator, NT-1505 tank.

**MAMMOTH 5-GALLON TANK $695**

Other models from $175. 2-year guarantee on all units.

SPECIFICATIONS

Interior Tank size (in.), 10W x 14L x 9½H. Tank Capacity, 5 gallons.

*Submersible Transducers*

Model NT-604 — Hermetically sealed heli-arc welded stainless steel case. Radiating face: 27 sq. in. Effective plane of radiation: 40 to 50 sq. in. (approx. 10" x 5"). Effective cavitation of volumes: up to 1200 cu. in. at 24" tank height (5 gal.) and 2400 cu. in. at 48" tank height (10 gal.). Swagelok tube fitting on side or end for internal tank wiring.

Model NT-605 — Same as NT-604 except for bulkhead fitting on back for external wiring. Eliminates electrical conduits in solutions.

**Now you can say goodbye to expensive chemicals, solvents, and degreasing equipment... reclaim valuable floor space... eliminate high installation costs... just by installing a Narda Series 1500 SonBlaster. At the same time, you'll get better, faster cleaning, and you'll need fewer people to do the job!**

**Get the tremendous activity of the new 300-watt Narda SonBlaster, with the largest transducerized tank ever made, at the lowest price in the industry! Choose from transducerized tanks or submersible transducers for use in any arrangement in any shape tank you desire. Up to 4 submersible transducers can be easily operated from the same generator at one time; load selector switch provided — an exclusive Narda feature.**

**Simply plug the SonBlaster into any 110-115 V AC line, and flip the switch. In seconds, you'll clean 'most any mechanical, optical, electrical, medical or horological part or assembly you can think of. Perfect, too, for brightening, polishing, radioactive decontaminating, pickling, quenching and plating; emulsifying, mixing, sterilizing, impregnating, degassing, and other chemical process applications.**

**Mail the coupon for free help in determining the model that's best for you.**

The SonBlaster catalog line of ultrasonic cleaning equipment ranges from 35 watts to 2.5 KW, and includes transducerized tanks as well as immersible transducers. If ultrasonics can be applied to help improve your process, Narda will recommend the finest, most dependable equipment available — and at the lowest price in the industry!

**The Narda Ultrasonics Corporation**
625 Main Street
Westbury, L. I., New York
Department AMM-6

Gentlemen:
Please send me more information about

☐ Series 1500 SonBlasters
☐ The complete Narda line

Name_____

Organization_____

Address_____

City_____

Zone____ State____

the narda ultrasonics corporation

625 MAIN STREET, WESTBURY, L. I., N. Y.

Subsidiary of The Narda Microwave Corporation

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# your date book

**october 26-30**
national conference
society of photographic scientists and engineers
edgewater beach hotel, chicago

◆

**october 28-30**
symposium on sealants
society of aircraft materials and process engineers
7660 W. Beverly Blvd., Los Angeles

◆

**november 2-4**
national midwestern meeting on new frontiers in aviation
institute of the aeronautical sciences
hotel lassen, wichita, kan.

◆

**november 2-6**
41st national metal exposition and congress
american society for metals
international amphitheatre, chicago

◆

**november 3-5**
11th annual mid-america electronics conference
kansas city-section, IRE
hotel muehlebach, kansas city

**november 4-6**
national automatic control conference
IRE, AIEE, IAS, ASME
sheraton hotel, dallas

◆

**november 9-11**
fourth instrumentation conference and exhibit
professional group on instrumentation and atlanta section IRE
atlanta biltmore hotel, atlanta

◆

**november 16-20**
international automation exposition and congress
trade show bldg., new york, n. y.

◆

**november 16-20**
14th annual meeting and astronautical exposition
american rocket society
sheraton park hotel, washington, d. c.

◆

**november 16-20**
annual convention
national aviation trades asso.
hotel montleone, new orleans

**november 17-18**
seminar on problems of machining Space Age metals
american society of tool engineers
sheraton hotel, philadelphia, pa.

◆

**november 17-18**
national turbine-powered air transportation meeting
institute of the aeronautical sciences
fairmont hotel, san francisco

◆

**november 17-19**
34th meeting
aviation distributors and manufacturers assn.
diplomat hotel, hollywood, fla.

◆

**november 17**
fall meeting
eastern div., society of aircraft materials & process engineers
sheraton-carlton hotel, washington, d. c.

◆

**november 19-20**
aircraft and missile div. conference
american society for quality control
sheraton-dallas hotel, dallas, tex.

◆

**november 23-24**
symposium on solid state techniques
phila. section, instrument society of america
ben franklin hotel, phila.

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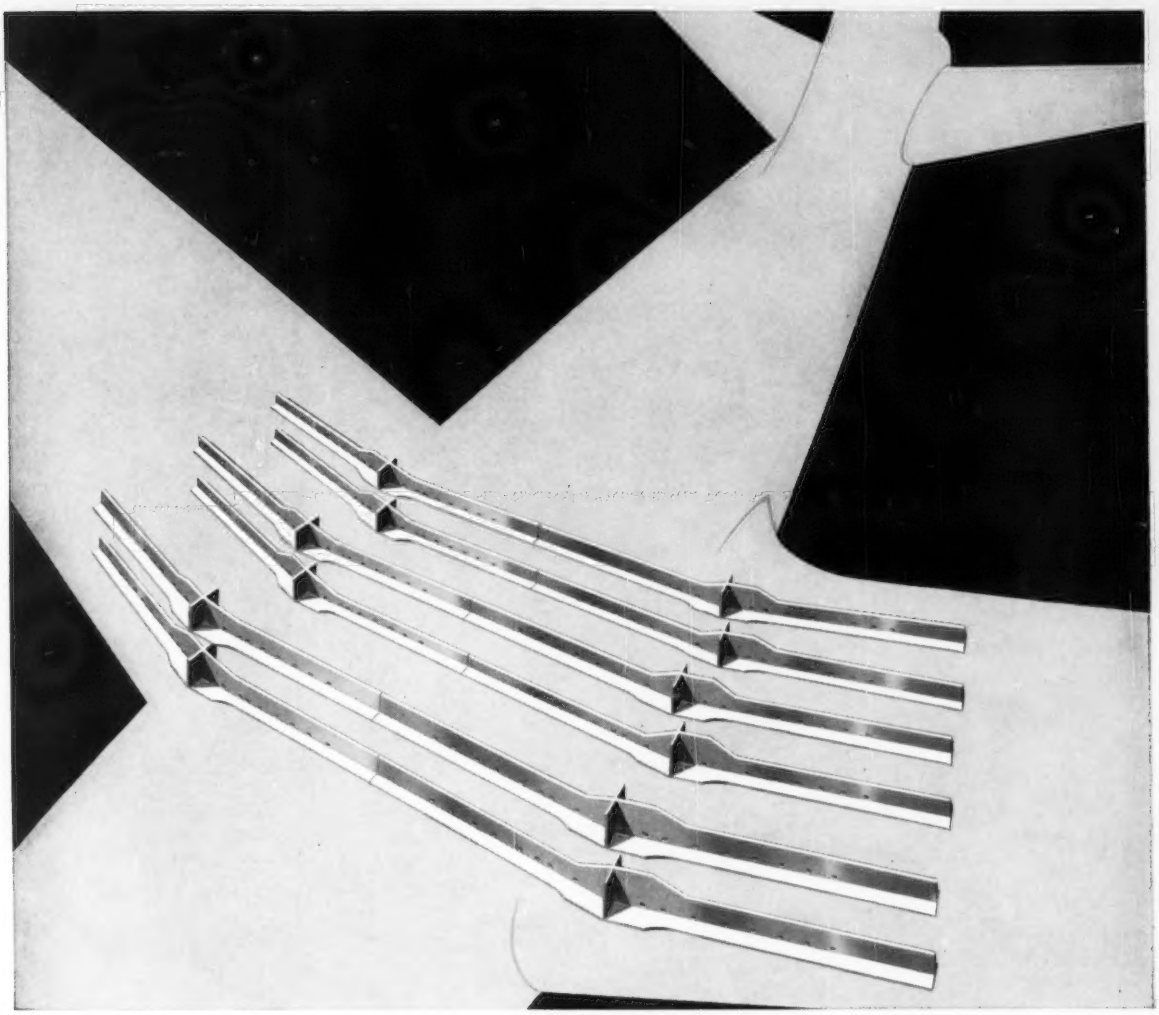

# 420 pounds of Alcoa Aluminum spar caps support 143-ton payloaded Douglas DC-8

**Twelve aluminum spar caps** are an integral part of the torque box that joins wing to fuselage and carries the entire 143-ton wing loading of the Douglas DC-8 Jetliner. Forged-in toughness of these caps is imparted under the pressure of Alcoa's 50,000-ton hydraulic press at Cleveland, Ohio. Weighing 294 lb each, the forged caps are machined and finished by Utility Metal Products, Div., Young Spring & Wire Corp., Pasadena, Calif. The caps are typical of the many complex structural parts for aircraft produced by Utility.

**At Utility,** 88 per cent of the metal disappears, a 35-lb gleaming wing spar emerges. This lightweight muscle and 11 others similar in configuration must not only carry a loaded plane in the air, but bear violent, repeated stresses of take-off and landing. It must also set sweepback of wing and dihedral angle.

**When 90 per cent machined,** spar caps are sent to Douglas, anodized and heat treated. Final straightening is followed by finish machining at Utility. All surfaces are handscraped to a 35 microfinish, each piece requiring 22 man-hours. Back at Douglas, caps are aged, again anodized, painted.

**Here is just one example** of Alcoa® Aluminum that leads a tortured life not only in the air, but in the machine shop beforehand. This caliber of performance means that the quality of the aluminum must be uniform in every ounce of the original forging, the original toughness retained in every linear inch of the finished cap. And it is . . . in Alcoa Aluminum. These are universal reasons for the choice of Alcoa Aluminum in difficult, demanding fabrications.

**How can you use** Alcoa Aluminum profitably? Find out. Contact our sales office or write Aluminum Company of America, 2032-L Alcoa Building, Pittsburgh 19, Pa.

ALCOA ALUMINUM

*Your Guide to the Best in Aluminum Value*

For exciting drama watch "Alcoa Presents" every Tuesday, ABC-TV, and the Emmy Award winning "Alcoa Theatre" alternate Mondays, NBC-TV

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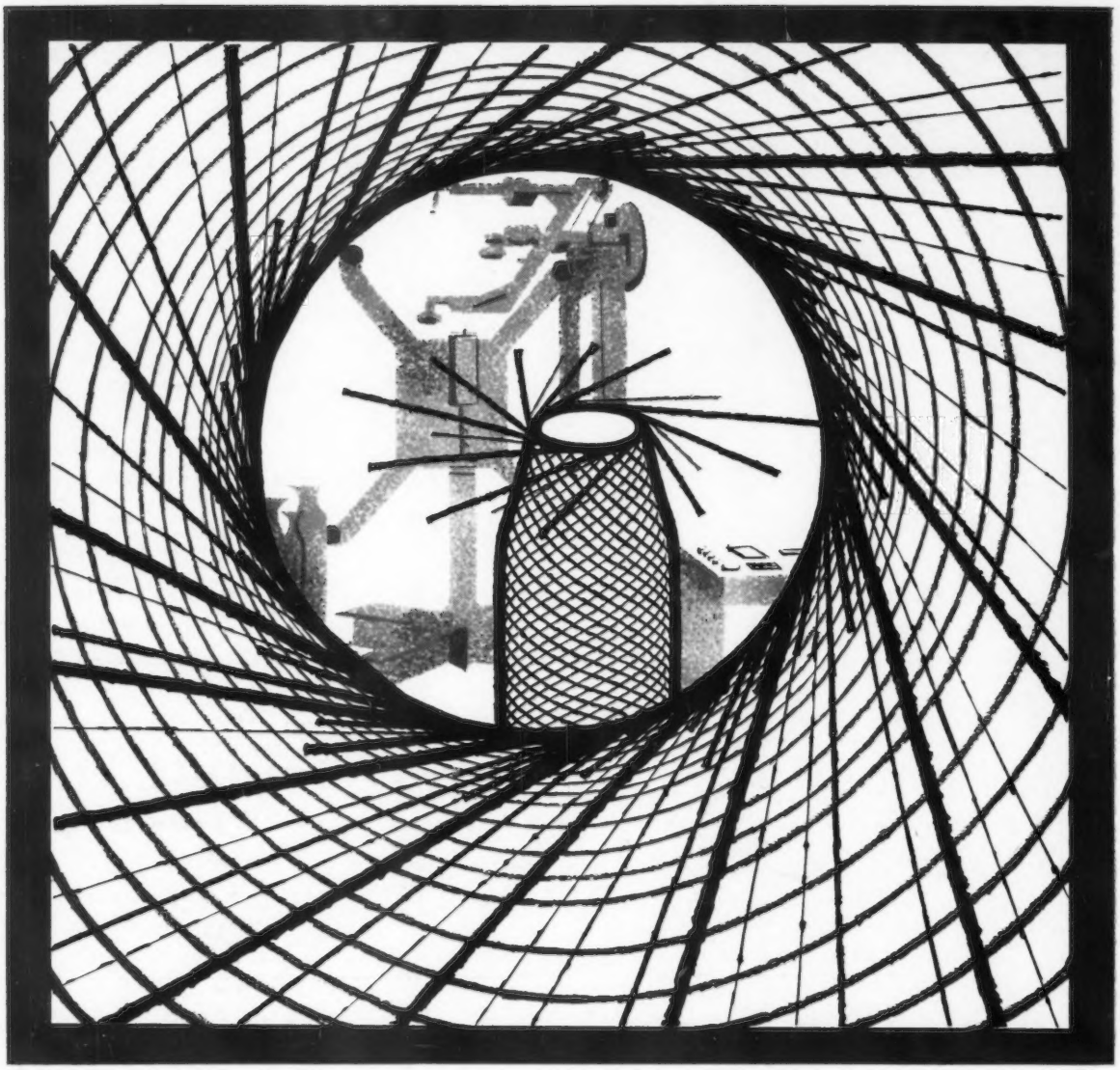

# BRUNSWICK WINDS S-D RATIOS UP TO 2,000,000!

You can get an idea of the remarkable power of Brunswick's exclusive Strickland "B" Process (SBP) from the fact that it winds fiberglass filament to a strength-density ratio of 2,000,000. (The SD ratio of high strength steels is 800,000.) The hoop tensile values of these products have averaged 200,000 psi, and their composite wall strengths range from 120,000 to 140,000 psi. SBP gives unmatched reliability and precision in the winding of structural elements, bodies, internally and externally loaded vessels and large cylinders. The process provides unusually close machine resin impregnation control, and variable control of glass density. The winding equipment shown above will produce units up to 12 feet long and 6 feet in diameter. With slight modifications, it will wind much larger units.

Get more information on how SBP can serve you. Write or call: The Brunswick-Balke-Collender Company, Defense Products Division Sales Manager, 1700 Messler Street, Muskegon, Michigan–today!

**BRUNSWICK**

MAKES YOUR IDEAS *WORK*

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